Buyers & Pillsbury

Steam Economy Tests Of a 60 Horse-Power Kerr Steam Turbine

Mechanical Engineering

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1908

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STEAM ECONOMY TESTS OF A 60 HORSE-POWER KERR STEAM TURBINE

BY

Archie Stanton Buyers
Charles Stephen Pillsbury

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN MECHANICAL ENGINEERING

IN THE
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OF THE
UNIVERSITY OF ILLINOIS
PRESENTED JUNE, 1908

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June 1, 1908

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

ARCHIE STANTON BUYERS CHARLES STEPHEN PILLSBURY

ENTITLED STEAM ECONOMY TESTS OF A 60 HORSE-POWER KERR STEAM TURBINE

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Mechanical Engineering

J. C. Thorpe

Instructor in Charge.

APPROVED: L. P. Breckenridge

HEAD OF DEPARTMENT OF Mechanical Engineering

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STEAM ECONOMY TESTS OF A 60 H.P. KERR STEAM TURBINE

I. Introduction:

The steam turbine is the newest of the different types of practical heat engines, yet its history is the longest of all. Every book on steam engineering contains a description of Hero of Alexandria's contrivance, the first heat engine of which any record has been preserved. This machine, really a reaction turbine, consisted of a sphere mounted on trunions through one of which steam was introduced from a small boiler. This sphere was rotated by the reaction of the steam as it escaped from two narrow tubes set opposite to one another on the equator of the sphere. This was about 200 B.C., and since then many attempts have been made to utilize the principle involved, but it was not until 1884 that the Parson's turbine proved the commercial value of the idea. With this year began the real history of the steam turbine, and a short time afterward, in 1889, De Laval brought out his turbine in the same form that is used to-day. These two machines are still the most typical examples of the leading forms of steam turbines.

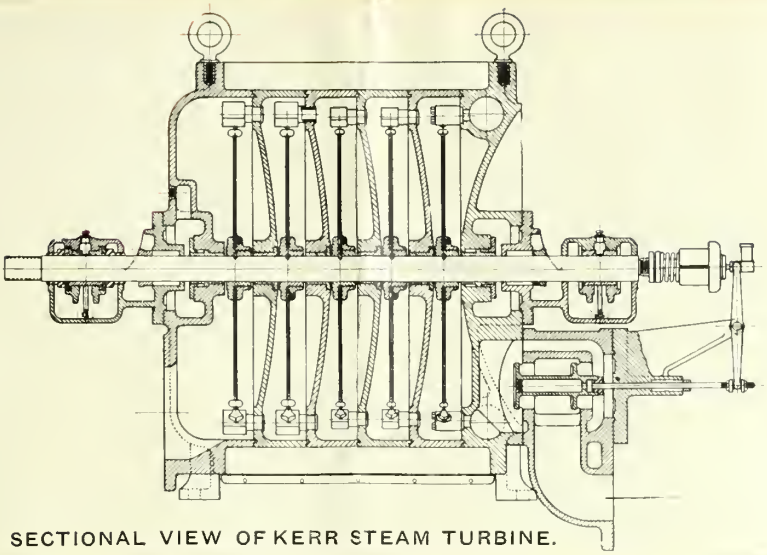
The De Laval is a typical impulse turbine, that is the steam has its heat energy exclusively turned into kinetic energy by its expansion from the initial pressure down to exhaust pressure in a single set of expanding nozzles. The power is developed by the jets of steam as they strike the blades on a moving rotor. No expansion whatever takes place after leaving the nozzles, and the work is due entirely to the kinetic energy given up to the blades by the steam. On the other hand, in the Parson's type the pressure decreases from one end of the turbine to the other, and the steam expands as it passes over the moving blades.

The essential difference between the impulse and reaction turbines is: that, in the former, the pressure is the same on both sides of a rotating wheel; in the latter, the pressure drops in passing over the blades, so that expansion and acceleration of the jet occur in each row of blades.

The Curtis is a well known example of the compound impulse turbine. It is divided into two or more compartments or stages in each of which are several moving bucket-wheels and corresponding intermediate stationary buckets. The steam is lead into each compartment by a set of nozzles, and the pressure is practically the same in all parts of the compartment.

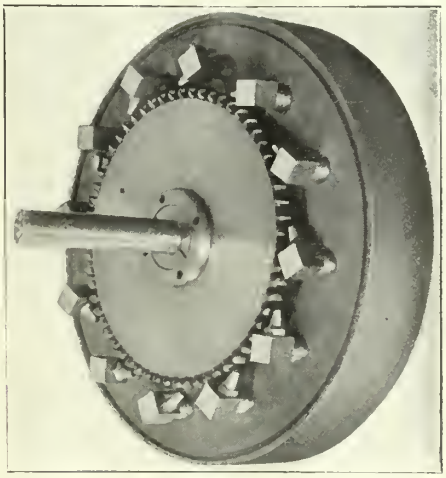
II. The Kerr Steam Turbine:

As compared with the guide and vane turbine of the reaction type, the Kerr steam turbine is a nozzle and bucket turbine of the typical impulse type. It is built on the principle of the Pelton water-wheel. The steam flows through a series of nozzles and impinges against the buckets of the first wheel which is located in a compartment by itself (see figures 1, 2 and 3). It then flows through another series of nozzles and impinges against the buckets of a second wheel in a second compartment. From here the steam passes through a third set of nozzles and so on through the series of stages to the exhaust. The exhaust under normal operation does not fall below atmospheric pressure, as the Kerr turbine is designed to run non-condensing. As might be expected the buckets and nozzles increase in size from one stage to another so as to provide for the larger volume of steam. Dividing the pressure drop into several stages makes possible a reasonably low speed of rotation, so that gears are avoided and direct coupling to driven machines is secured. The Pelton type of bucket obtains the complete reversal of the steam jet and is independent



SECTIONAL VIEW OF KERR STEAM TURBINE.

FIGURE 1.



BUCKET WHEEL AND NOZZLES.

FIGURE 2.

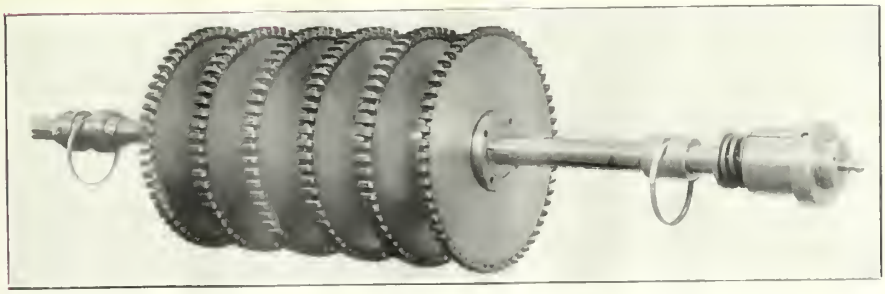
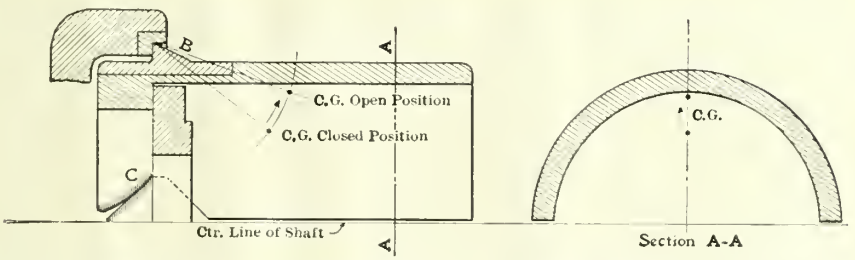


FIG. 2. SHOWING A NUMBER OF DISKS ON SHAFT

FIGURE 3.

of leakage losses through clearance spaces. It is thus peculiarly adapted to the use of high steam pressures and superheat, while an increase in vacuum will not show an increased efficiency similar to that given by a Curtis turbine with low exhaust pressure.

The throttling type of governor is used as shown in Fig. 4. The outward movement of the weights compresses a spring and operates the balanced piston valve through lever connections. This type of governor is very simple, and at



ARRANGEMENT AND CONSTRU CTION OF GOVERNOR WEIGHTS.

FIGURE 4.

light loads it tends to superheat the steam and thus reduce the windage losses. The internal friction of a turbine depends so largely upon the quality of the steam that this throttling ensures a minimum friction loss and makes the brake horse power nearly proportional to the steam pressure.

The lubrication of the machine is confined to the two ring-oiling, main bearings and to the governor pivot block which is provided with an oil reservoir. There are no internal rubbing parts to require lubrication. The exhaust steam is, therefore, free from oil, and it may be used for any purpose for which clean low pressure steam is adapted. The body of the turbine is lagged to prevent radiation, and is covered with a sheet-steel jacket. Leakage of steam around the shaft at both ends is prevented by combining metallic and

fibrous packing. What little steam leaks through the metallic packing is piped back to a lower stage of the turbine.

Among the high-speed machines which the Kerr turbine is especially adapted to driving are electric generators, pressure-blowers and centrifugal pumps. The turbo-generator unit usually runs at about 3000 RPM and gives efficient service with very little noise, vibration, or sparking. The development of the turbine form of centrifugal pump in late years for high-pressure work makes the application of this form of driving easy. One common use is the handling of circulating water for condensing plants and for boiler feeding. The third application to which this turbine is well adapted is that of driving pressure-blowers to supply blast for forges, cupolas and gas generators.

A great advantage of the Kerr turbine is the fact that it can reach full speed from a complete standstill in from five to six seconds. In an emergency the turbine can be started with full steam pressure admitted to the cold turbine without danger. The sectional construction of the turbine, and the absence of small running clearance, avoid trouble due to heat expansion almost entirely.

III. Object of Tests:

The object of these tests is to determine the steam economies of the 60 H.P. Kerr steam turbine in the Mechanical Engineering Laboratory of the University of Illinois running non-condensing with saturated steam at different loads from zero to the maximum at the following steam pressures: 105 lbs.; 120 lbs.; 135 lbs.; 150 lbs.

IV. Description of Apparatus:

(1) Turbine:

The turbine tested is an 18", 6 stage impulse turbine rated at 60 B.H.P. at 150 pounds pressure non-condensing, and is manufactured by the Kerr Turbine Co., Wellsville, New York. For a general view of the machines, see Fig. 5.

(2) Auxiliary Apparatus:

The steam was condensed at atmospheric pressure by a Wheeler Surface Condenser, built by the Wheeler Condenser and Engineering Co., New York. The condenser contains 225 square feet of condensing surface, and has a capacity of 60 H.P. The cooling water, which is circulated by a steam pump on the condenser, was drawn from a near-by creek. Leakage tests were run several different times on the condenser by shutting down the turbine and letting the air and circulating pumps continue as before. In every case after a short period, no more water was drawn out by the air pump, so that there was no condenser leakage.

(3) Instruments and their Calibration:

The instruments and smaller apparatus used were:

Pressure gages,

Thermometers,

Prony Brake,

Brake Standard,

Platform Scales,

Calorimeter,

Speed Counter.

The above were compared with approved standards and the readings taken were corrected accordingly.

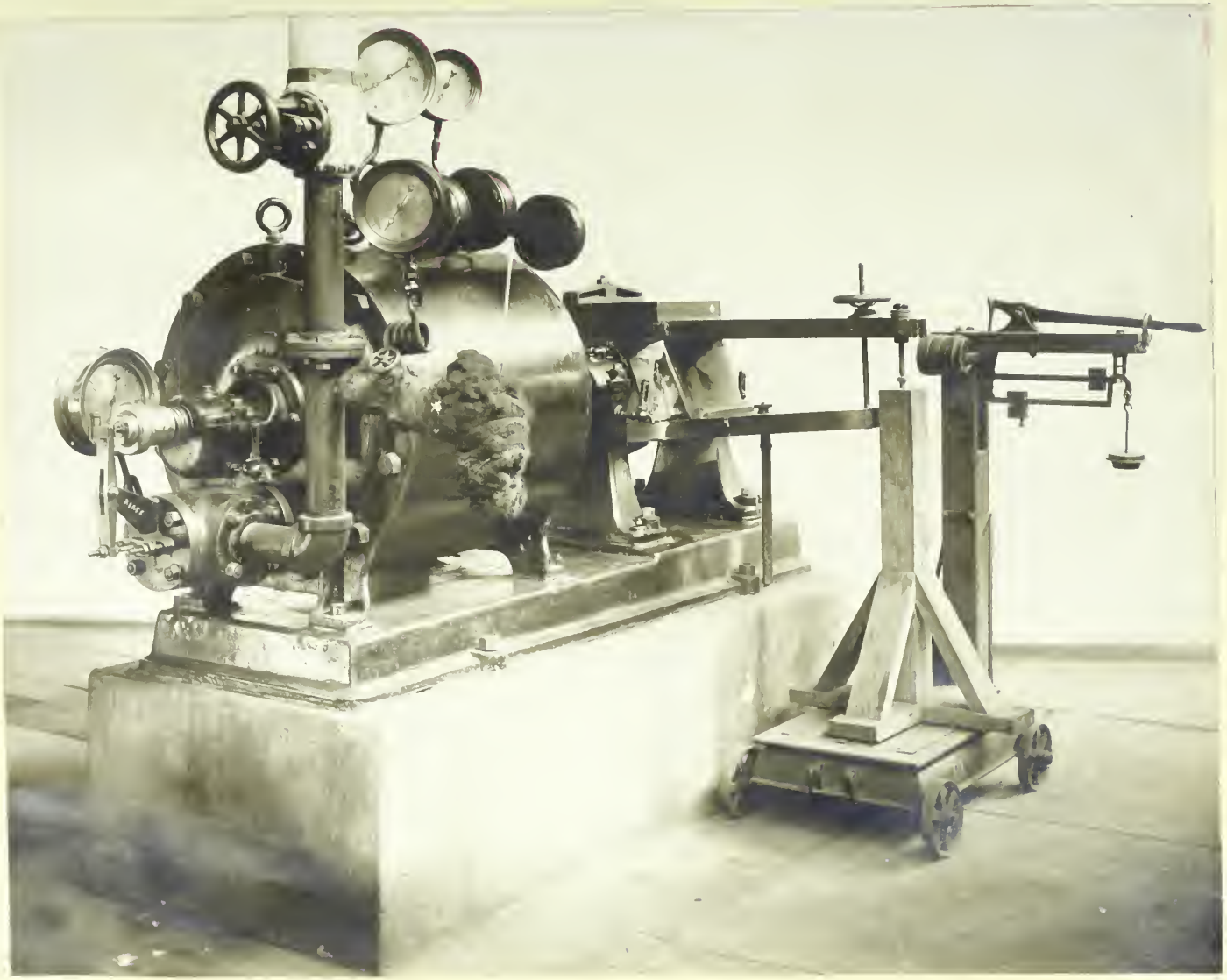


FIGURE 5 - GENERAL VIEW OF TURBINE.

V. Method of Conducting Tests:

A series of tests was run at the following steam main pressures: 105 lbs., 120 lbs., 135 lbs., and 150 lbs. gage. As far as possible tests were made at 0, 1/4, 1/2, 3/4, and full load. The tests, except in the case of the zero loads, lasted two hours, with readings every five minutes. There were four observers to take the following readings:

Weight of condensed steam

RPM

Steam main pressure

Calorimeter pressure

Calorimeter temperature

Barometer

Temperature in each stage

Pressure in each stage

Engine room temperature

External air temperature

VI. Discussion of the Data:

The observed data were corrected from the calibrations before being placed on the data sheets. There are several inconsistencies apparent that are due to external circumstances. All the results in regard to steam consumption are consistent, except for the zero loads and for the quarter load at 150 lbs. steam main pressure. The variation in this case is probably due to the fact that one of the stages was removed during the Christmas holidays for experimental purposes, and when replaced the adjustment of the machine was disturbed. The temperature curves for the zero loads show that the thermometer calibrations

were not accurate for temperatures close to 212° F. An interesting fact is indicated by comparing the temperatures as read to the temperatures in the steam tables correcponding to the steam pressure in each stage. In every case the thermometers read from 5°-8° F lower than they should. This shows that the thermometer cups are not deep enough, or else it shows loss of heat due to air currents around the upper part of the thermometers.

It will be noticed that the initial pressure, after passing the throttle valve, was constant for each load regardless of the steam main pressure. This indicates that for light loads the steam main pressure has little effect upon the steam economy.

VII. Calculations:

The calculated data consists of the following:

1. B.T.U.,
2. Quality of entering steam,
3. Water rate per B.H.P. hour,
4. Thermal effeciency based on B.H.P.

Sample calculation for test number 2.

Power

$$BHP = \frac{2\pi RWN}{33000}$$

When R = length of brake arm in feet = 2.50

W = net weight on brake scales = 26.45

N = average R.P.M. of turbine = 3618.

$$BHP = \frac{2 \times \pi \times 2.5 \times 26.45 \times 3618}{33000}$$

$$= 45.3$$

Quality:

Barometer = 28.64 or atmospheric pressure = 14.06

Temp. corresponding to 14.06 lbs. press. = 211.6

Pressure in calorimeter = 150.8 + 14.1 = 164.9 absolute

Temperature in calorimeter = 258.4

Degrees superheat is calorimeter = 258.4 - 211.6 = 46.8

But $a_1 + x_1 L_1 = H_a + .48\ (T_2 - T_a)$

a_1 = heat of liquid in wet steam = 337.6

x_1 = quality of steam

L_1 = latent heat of wet steam = 855.8

H_a = total heat atmospheric press = 1146.0

T_2 = temperature in calorimeter = 258.4

T_a = temperature of atmosphere = 211.6

$$x_1 = \frac{H_a + .48\ (T_2 - T_a) - a_1}{L_1}$$

$$= \frac{1146.0 + .48 \times 46.8 - 337.6}{855.8}$$

$$= .972$$

Steam Economy:

Wet steam used in two hours = 3880 lbs.

Dry steam used per hour $= \frac{3880 \times .972}{2} = 1885$

Economy in lbs. per BHP $= \frac{1885}{45.3} = 41.5$

Thermal Efficiency:

$$\text{Thermal eff.} = \frac{\text{BTU per H.P. hour}}{\text{BTU in entering steam - BTU in condensed steam}}$$

BTU per H.P. hour = 2545

BTU in 1 lb. entering steam = 1170

BTU in 1 lb. condensed steam = 177.8

$$\therefore \text{Thermal eff.} = \frac{2545}{(1170 - 177.8) \times 41.5} = .0602$$

In addition to the above the potential efficiency was calculuated for full load at 150 lbs. steam main pressure as follows:

Potential efficiency is the ratio of the B.T.U. equivalent of the work delivered at the brake per pound of steam to heat drop in B.T.U. due to adiabatic expansion from the initial to the final state.

$$\text{Heat delivered at brake} = \frac{2545}{\text{lbs. steam per BHP hour}}$$

$$= \frac{2545}{39.2} = 65. \text{ B.T.U.}$$

From a total heat-entropy chart the heat in the steam at 165.2 lbs. absolute and .976 quality is 1173 B.T.U. At atmospheric pressure after adiabatic expansion the total heat in the steam is 1001 B.T.U. Or the heat delivered in an ideal adiabatic expansion would be 1173-1001 = 172 B T U

$$\text{Or Potential Efficiency} = \frac{65 \times 100}{172} = 37.8\%$$

VIII. Curves:

On page 15 is shown a curve for each series of tests with steam economics as ordinates and B.H.P. as abscissae. As should be expected the water rate becomes lower as the steam pressure is increased.

On page 16 is shown the variation of the steam economy with the steam pressure when the load is kept constant. Better results are shown as the pressure is increased, and the greater the load the less is the water rate.

On page 17 are shown the steam flow curves for the different pressures. These are supplementary to the economy curves.

The pressures and temperatures in the different stages under varying conditions are plotted in the form of curves on pages 18 to 25.

The lines between the points do not have any significance but the fact that the points lie on a smooth curve indicates good design. The lower of two successive stage pressures is in no case less than .58 of the higher, so it is not necessary to use expanding nozzles in order to fully utilize the potential energy of the steam. Experiments have shown that .58 is the maximum pressure drop attainable in an ordinary nozzle. When the lower pressure is less than this amount, further expansion takes place after leaving the nozzles in such a way as to destroy the effectiveness of the steam jet.

IX. Conclusions:

The turbine is rated by the builders to run non-condensing with a steam pressure of 150 lbs. at a speed of 3600 R.P.M., and, under these conditions, to develop 60 B.H.P. The economy is not fixed in the guarantee, but was to be similar to a sample curve which gives an economy of 34 lbs. per HP hour at full load and 44.5 lbs. at quarter load. Actual results with the corresponding steam pressure, show 39.2 lbs. at full and 60 lbs. at quarter load. The curve sent out by the builders also shows a point at quarter over-load, but the highest power actually obtainable is a little less than full load.

It is evident from the above that this machine does not come up to the guarantee, either in power or economy. The economy actually shown is fairly good for a small steam turbine and is near the average results for reciprocating engines of similar capacities. After all, in so small a unit, low steam consumption is of secondary importance to reliability. In this respect, the Kerr turbine has an advantage over a reciprocating engine of the same size, since it

has no valves to wear or get out of order. It requires no attendance, except to fill the oil reservoirs,and it can be depended upon for consistent service.

The potential efficiency 37.8% is low compared to 60% - 80% as attained by larger machines, but it is fair for a small unit. An example of high speed reciprocating engine practice presents a potential efficiency of 45-50%.

X. References:

Power - February, 1905 - "Kerr Compound Steam Turbine."

Thomas - "Steam Turbine", pp. 93-94.

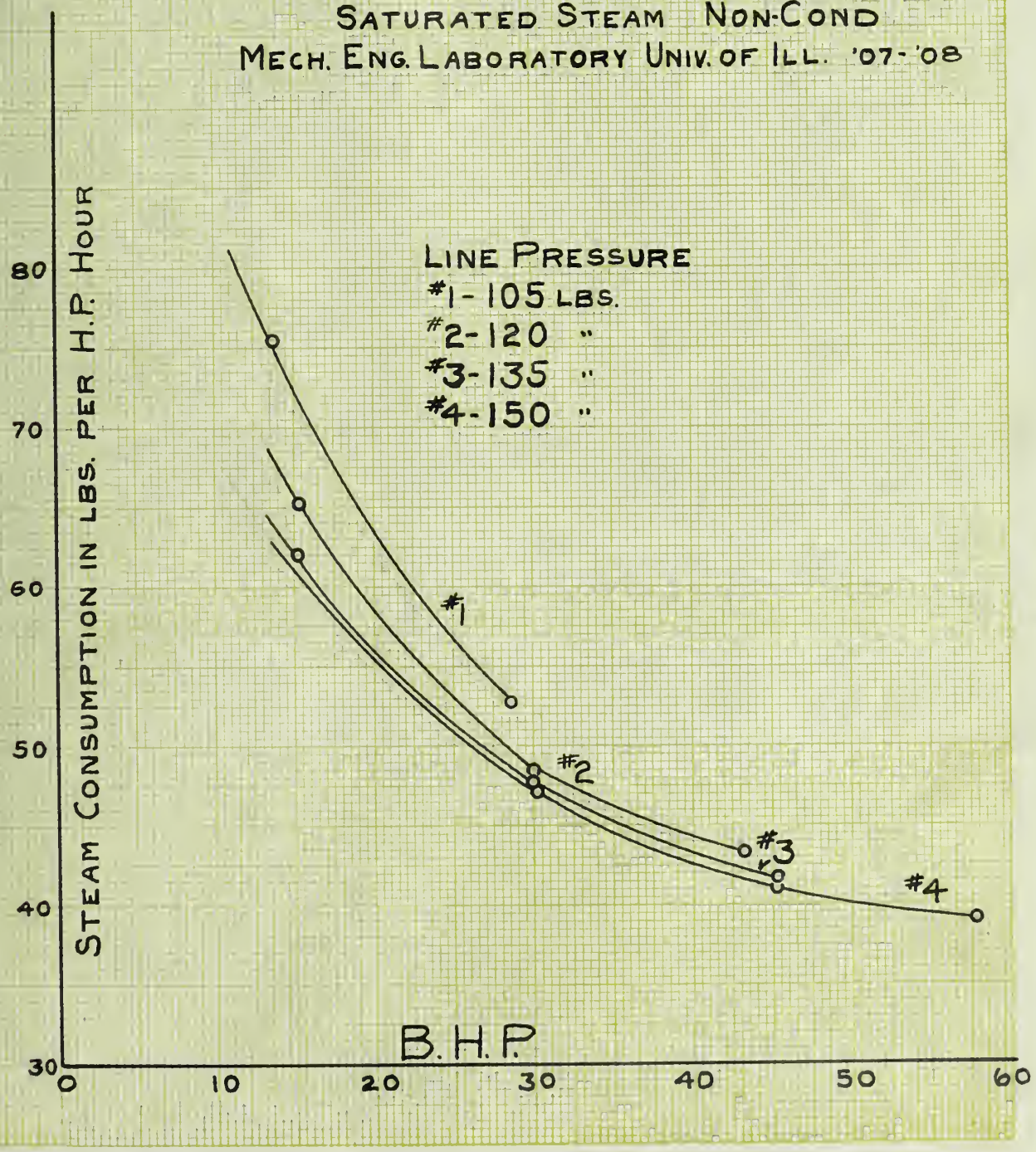
American Machinist - Jan. 18, 1906 - "The Kerr Steam Turbine."

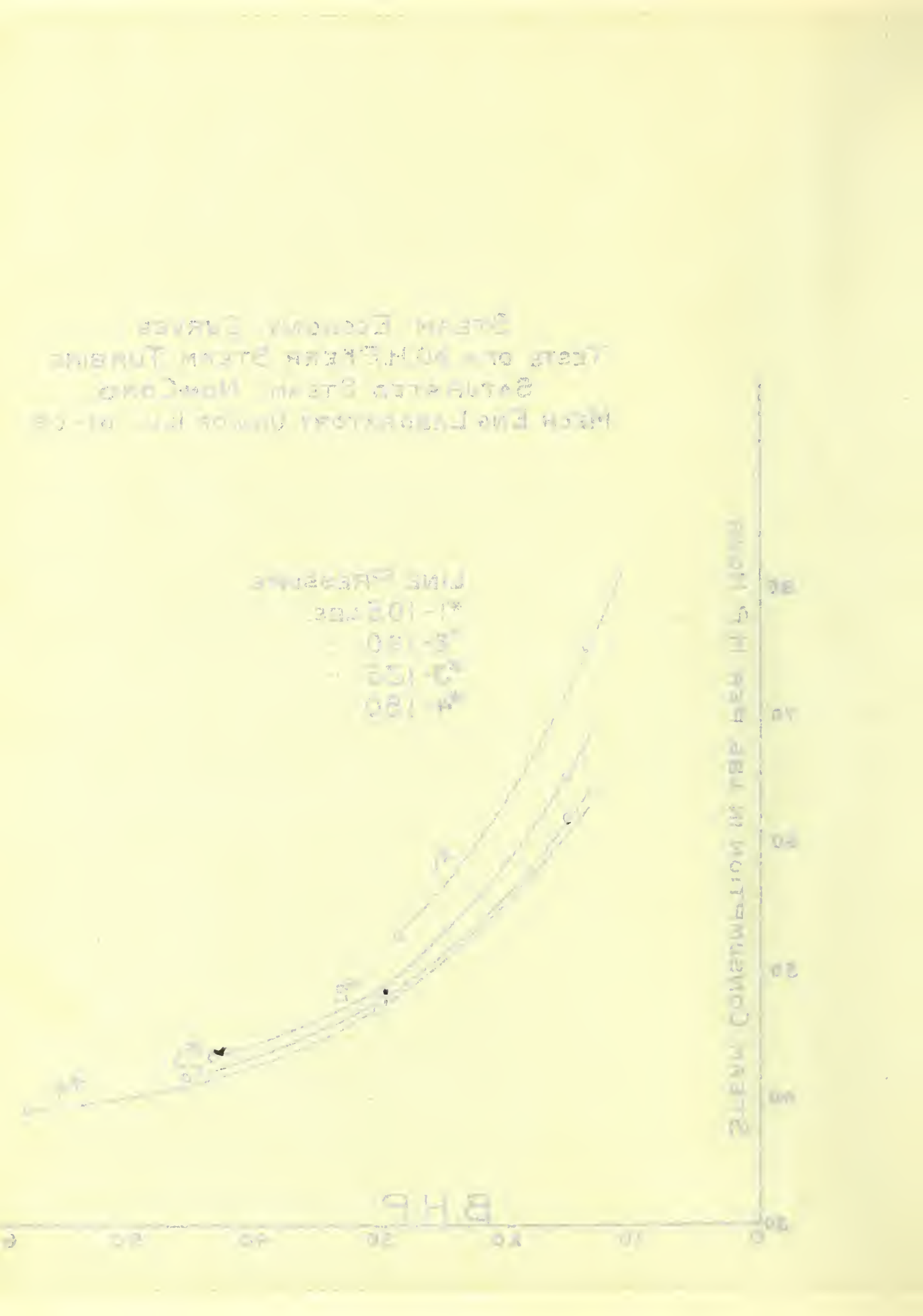
The Engineer - Jan. 1, 1903 - "The Kerr Steam Turbine."

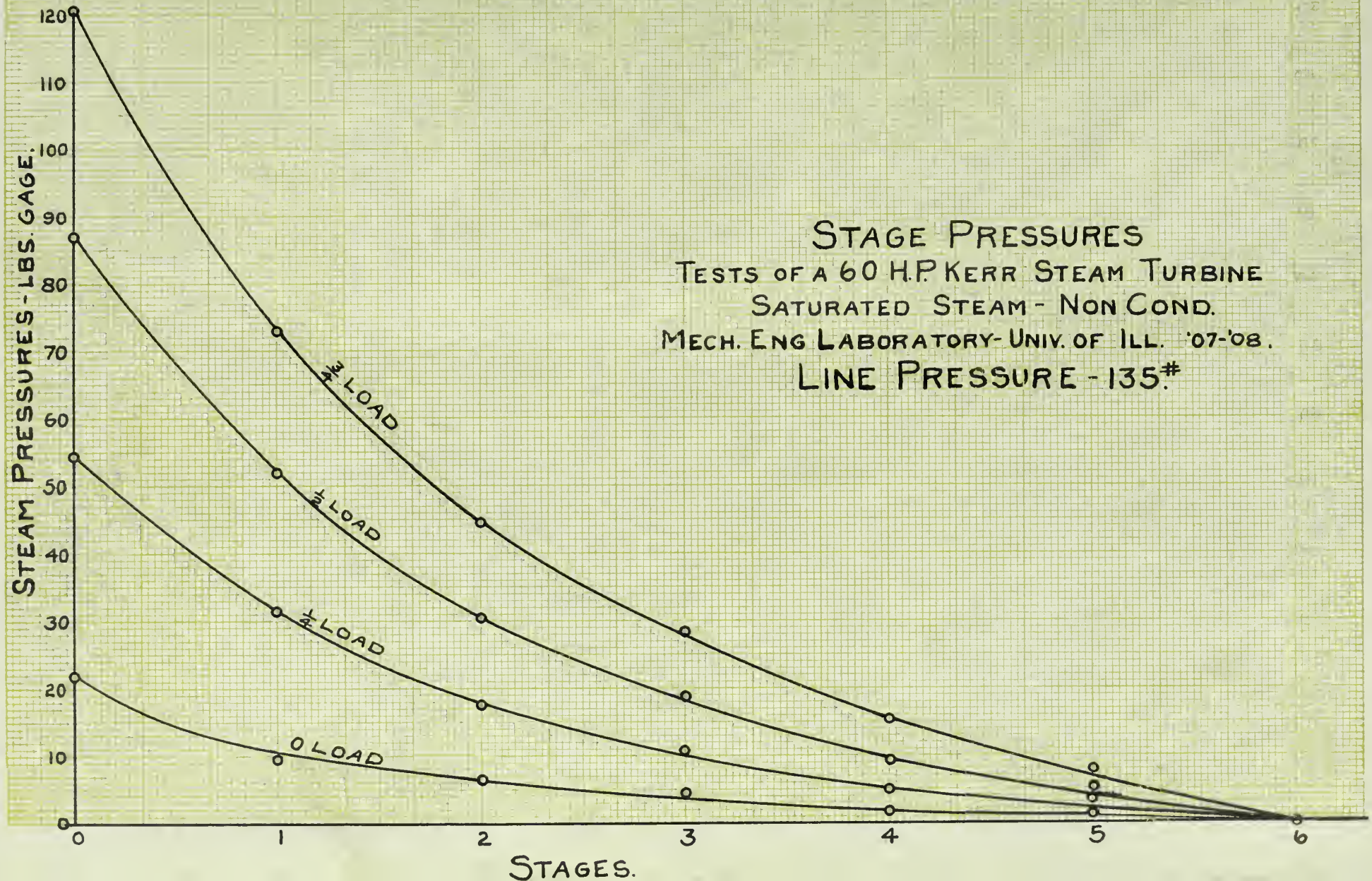
TABLE OF STEAM ECONOMIES

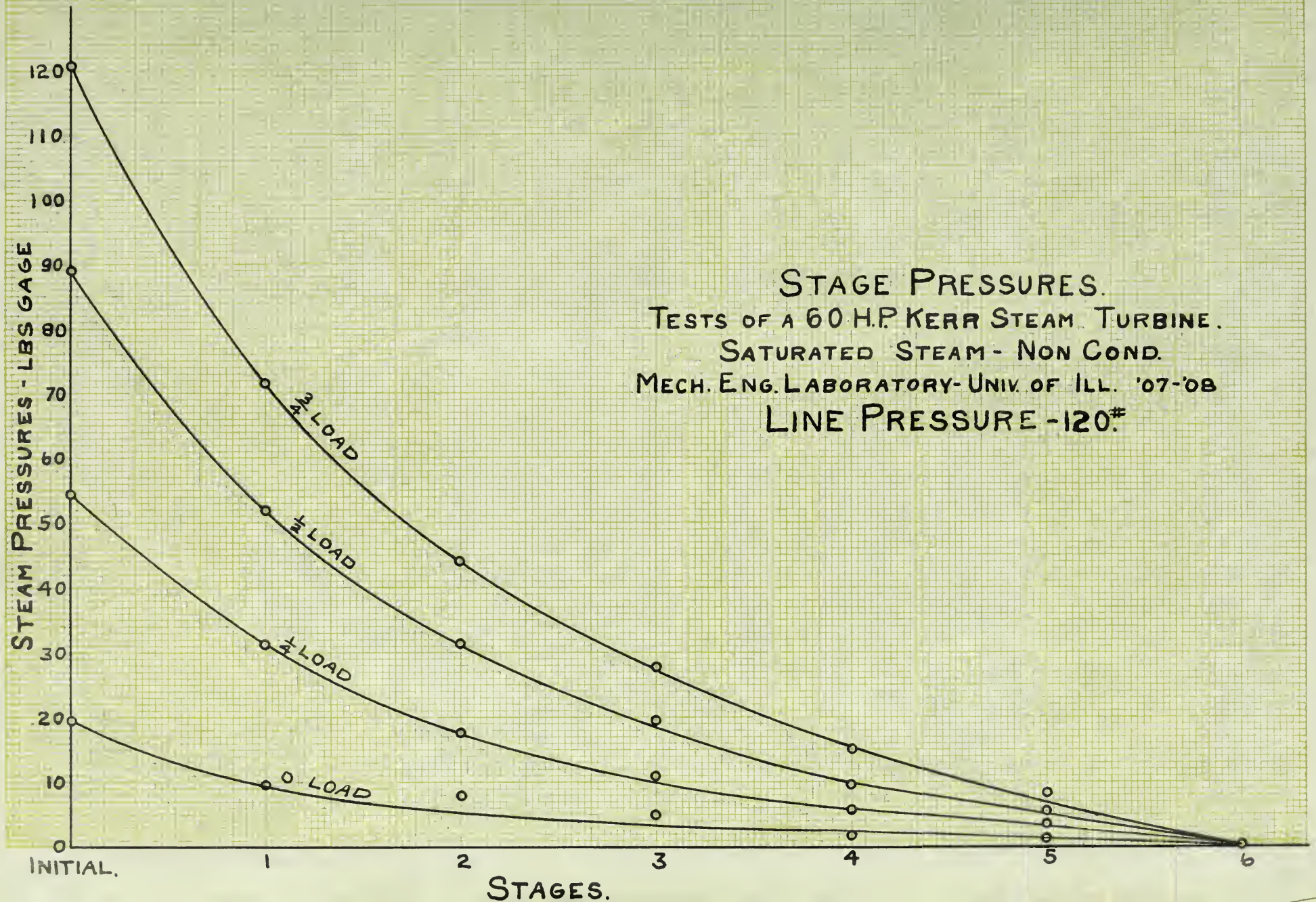
Load	Steam Main Pressure - Lb. Gage			
	105	120	135	150
1/4	75.6	65.1	62.0	67.2
1/2	52.7	48.4	47.7	47.5
3/4		44.4	41.8	41.5
1				39.2

Steam Economy Curves
Tests of a 60 H.P. Kerr Steam Turbine
Saturated Steam Non-Cond
Mech. Eng. Laboratory Univ. of Ill. '07-'08

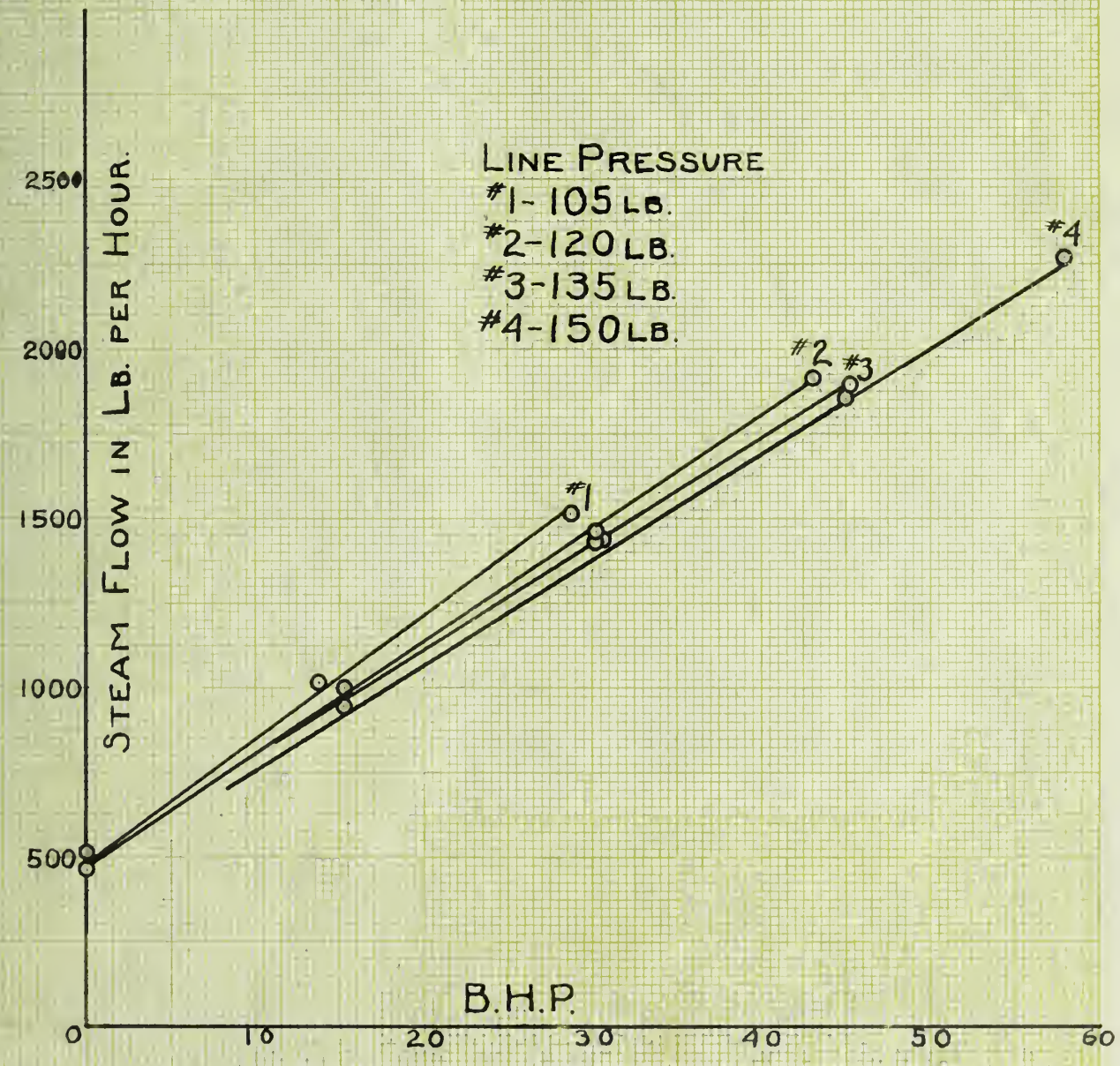


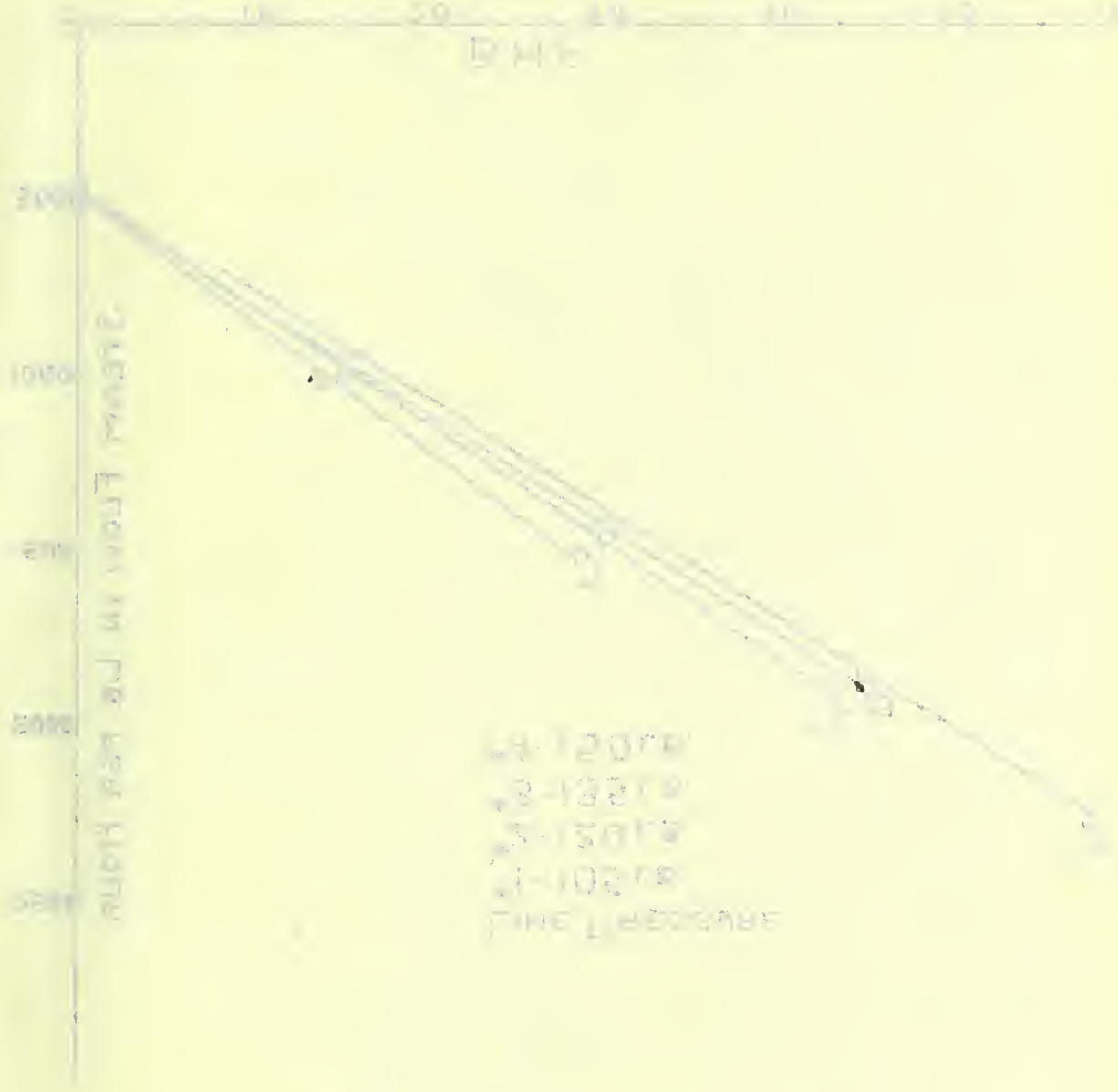



STAGE PRESSURES
TESTS OF A 60 H.P. KERR STEAM TURBINE
SATURATED STEAM - NON COND.
MECH. ENG LABORATORY - UNIV. OF ILL. '07-'08.
LINE PRESSURE - 135#
STEAM PRESSURES - LBS. GAGE.
120
110
100
90
80
70
60
50
40
30
20
10
0
3/4 LOAD
1/2 LOAD
1/4 LOAD
0 LOAD
0
1
2
3
4
5
6
STAGES.


STAGE PRESSURES.
TESTS OF A 60 H.P. KERR STEAM TURBINE.
SATURATED STEAM - NON COND.
MECH. ENG. LABORATORY - UNIV. OF ILL. '07-'08
LINE PRESSURE - 120#
STEAM PRESSURES - LBS GAGE
120
110
100
90
80
70
60
50
40
30
20
10
0
¾ LOAD
½ LOAD
¼ LOAD
0 LOAD
INITIAL.
1
2
3
4
5
6
STAGES.

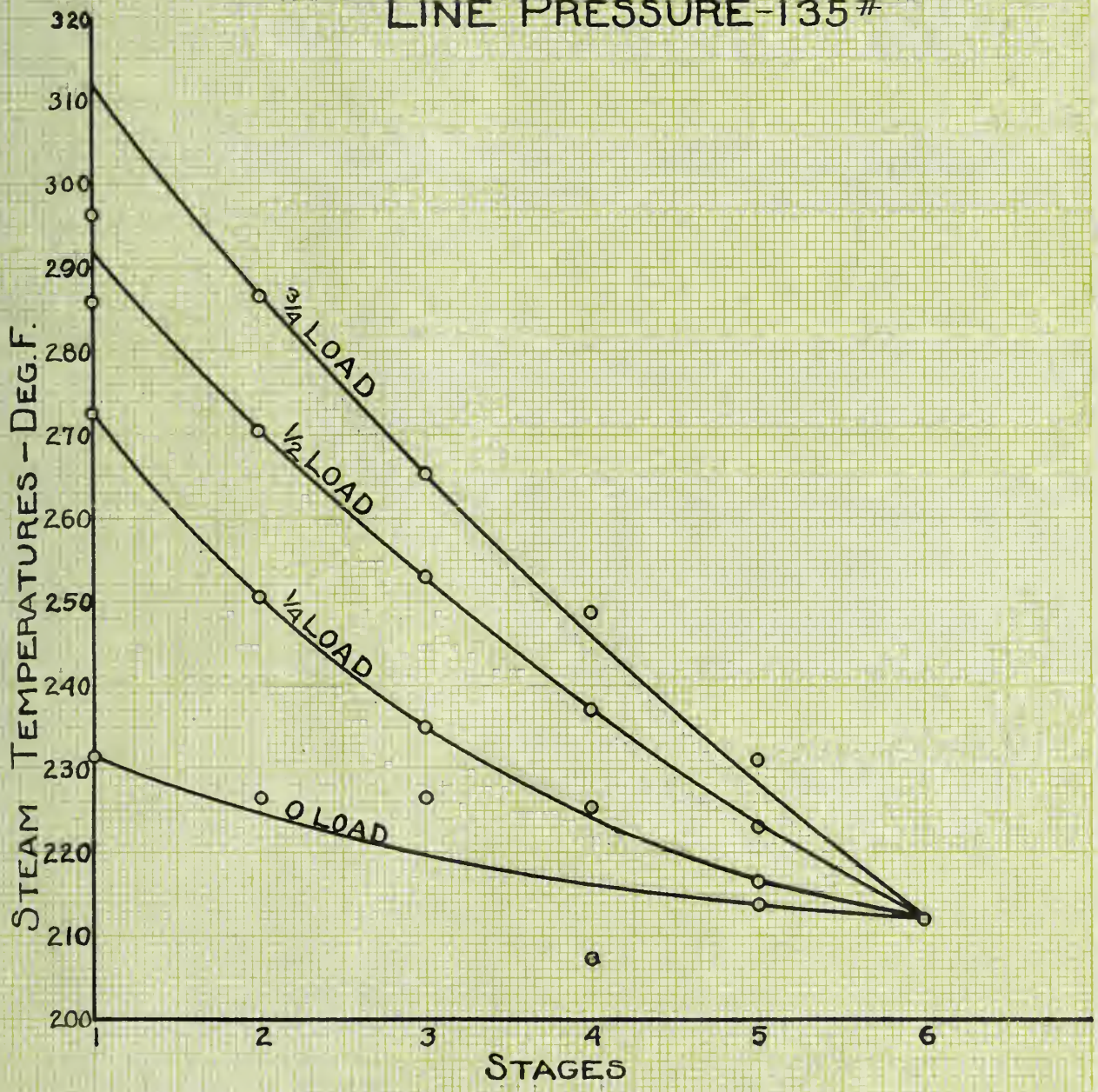
Steam Flow Curves
Tests of a 60 H.P. Kerr Steam Turbine
Saturated Steam Non-Cond.
Mech. Eng. Laboratory Univ. of Ill. '07-'08

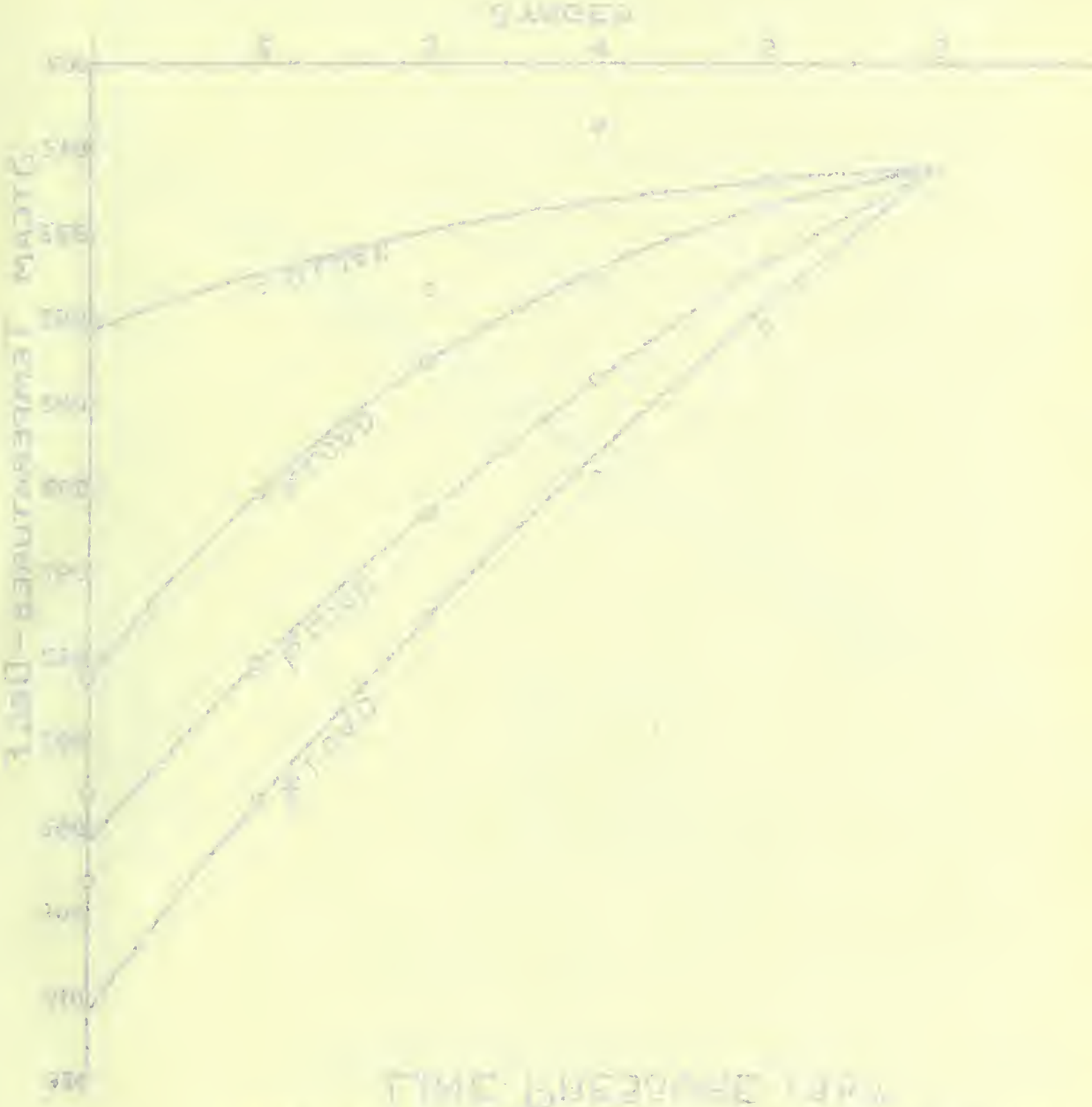




STAGE TEMPERATURES

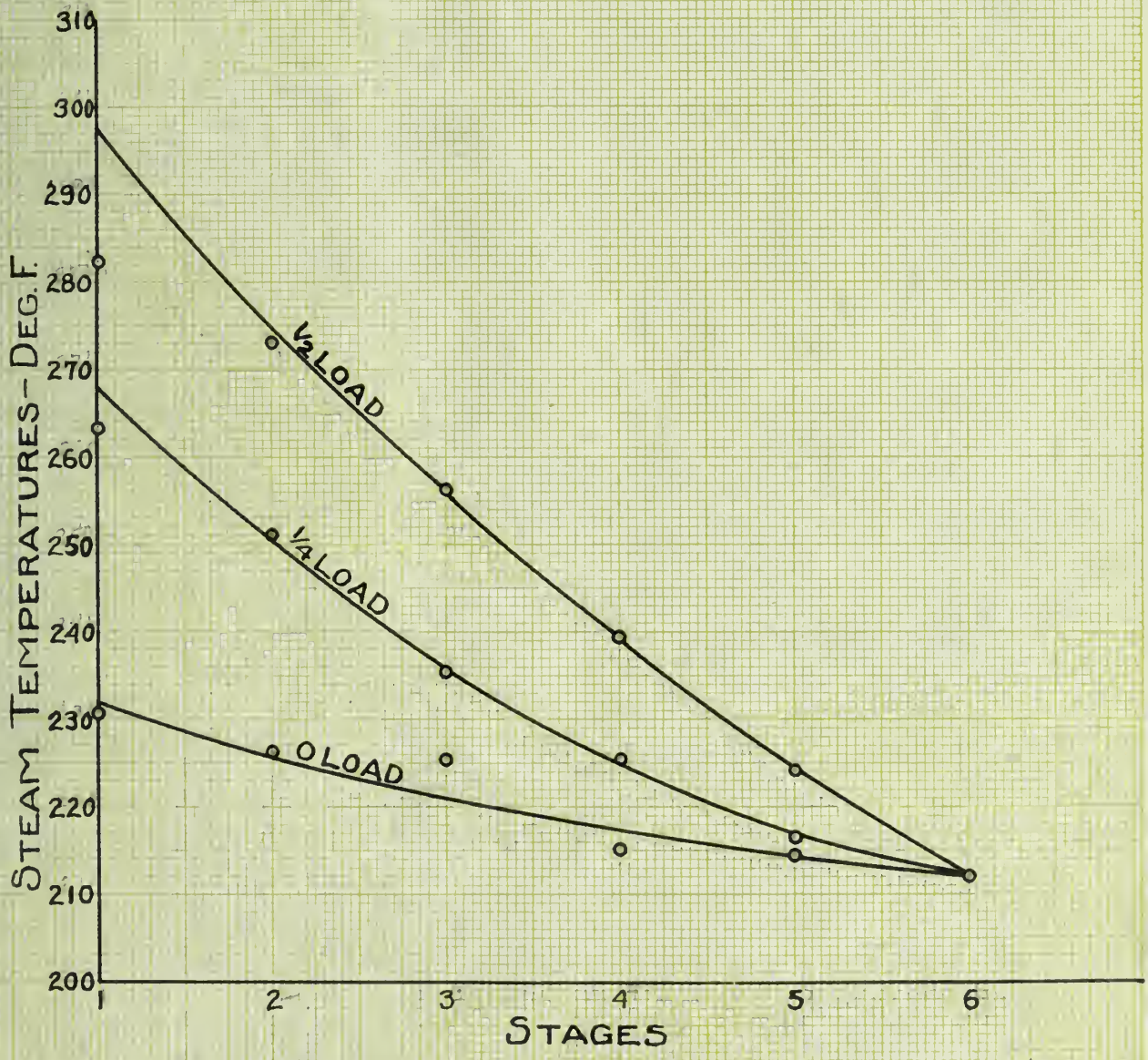
TESTS OF A 60 H.P. KERR STEAM TURBINE
SATURATED STEAM NON-COND.
MECH. ENG. LABORATORY - UNIV. OF ILL. '07-'08
LINE PRESSURE-135#

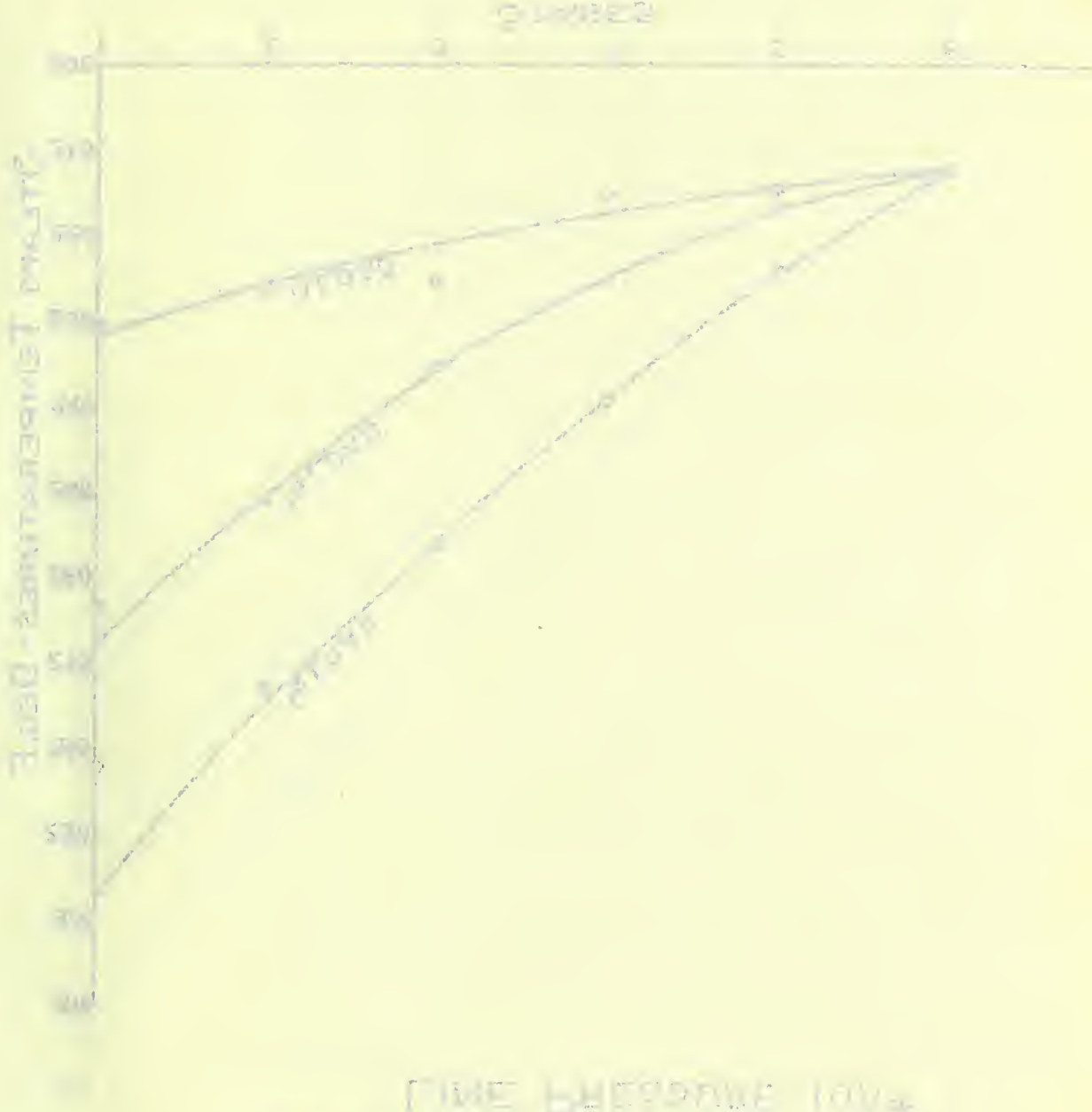


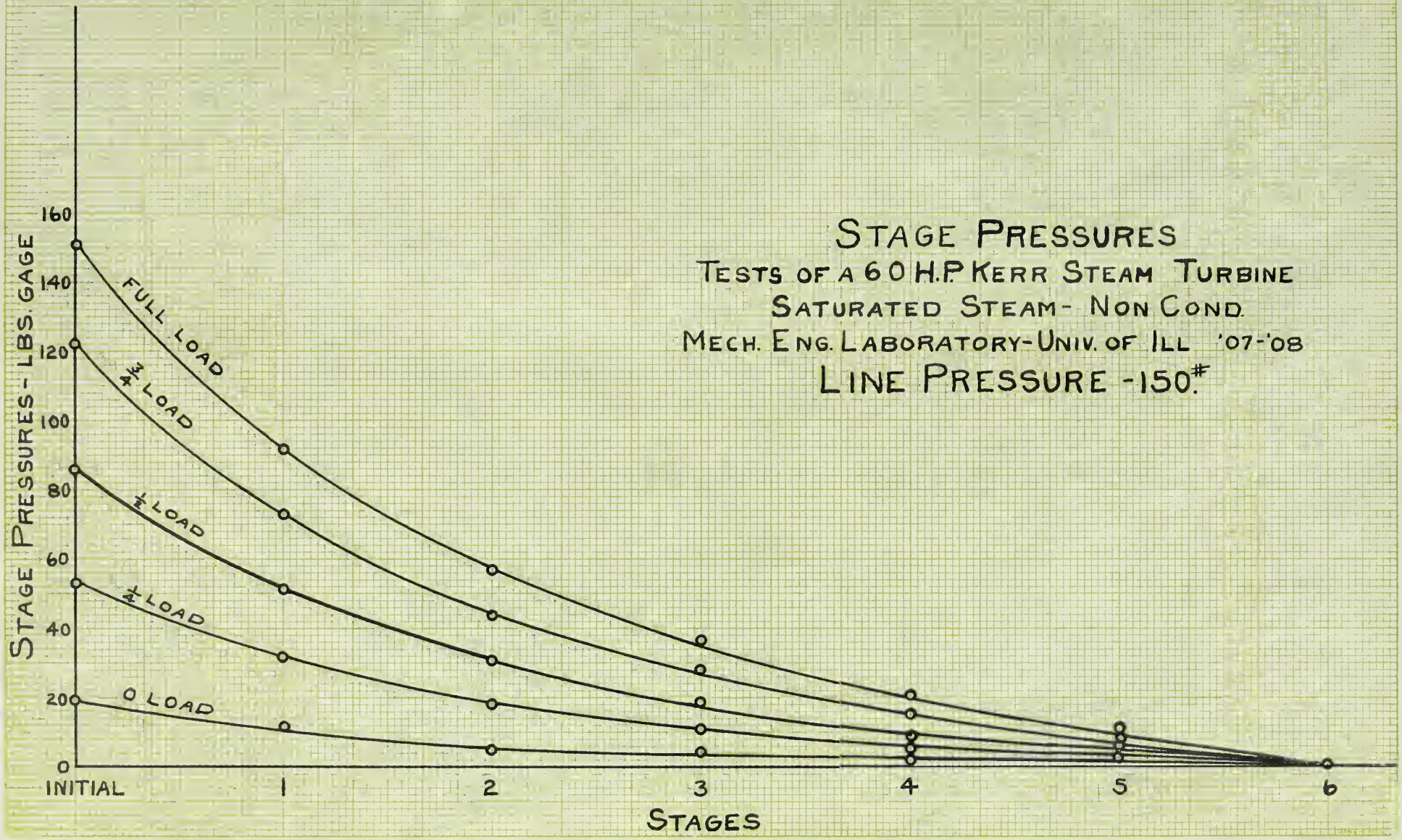


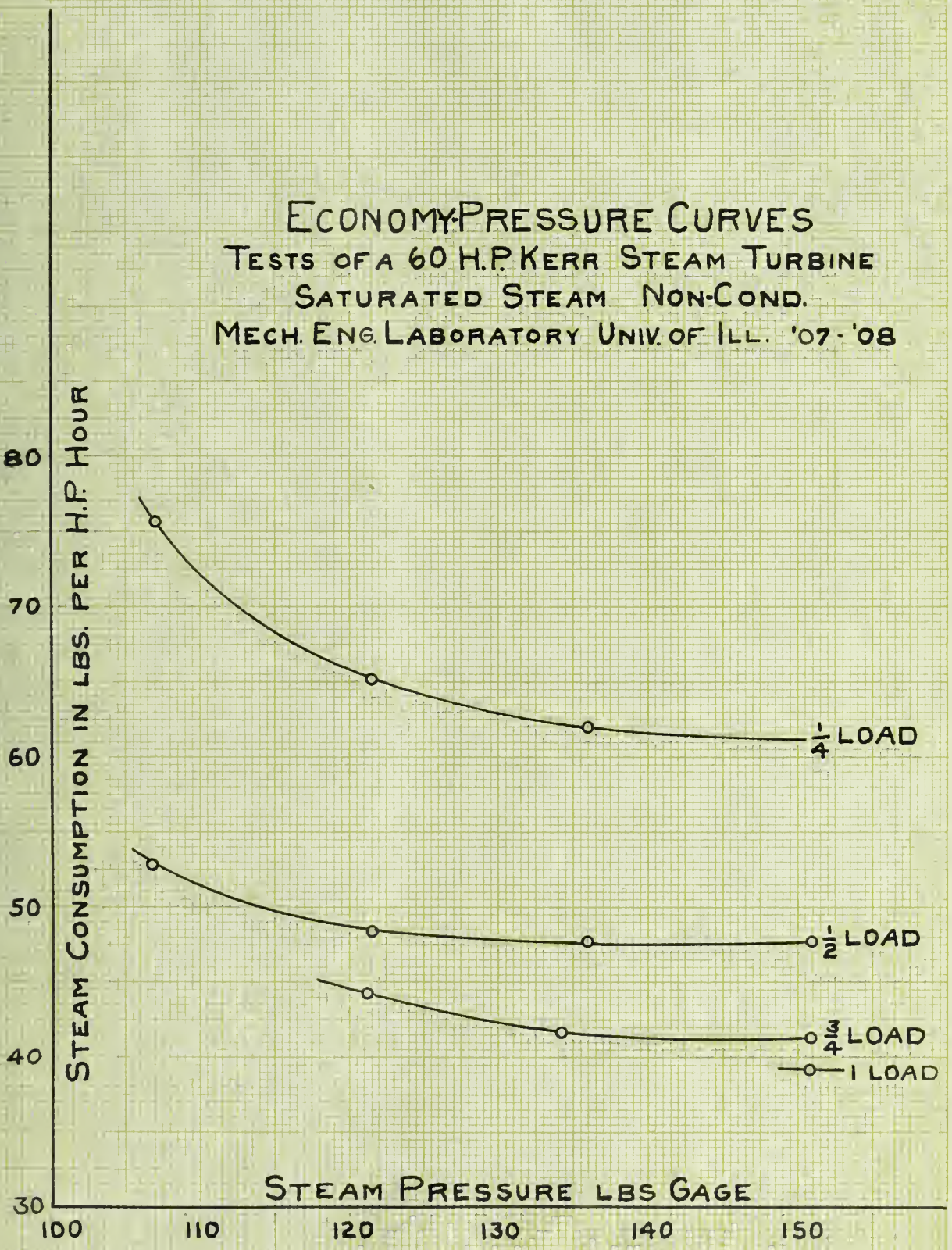
STAGE TEMPERATURES

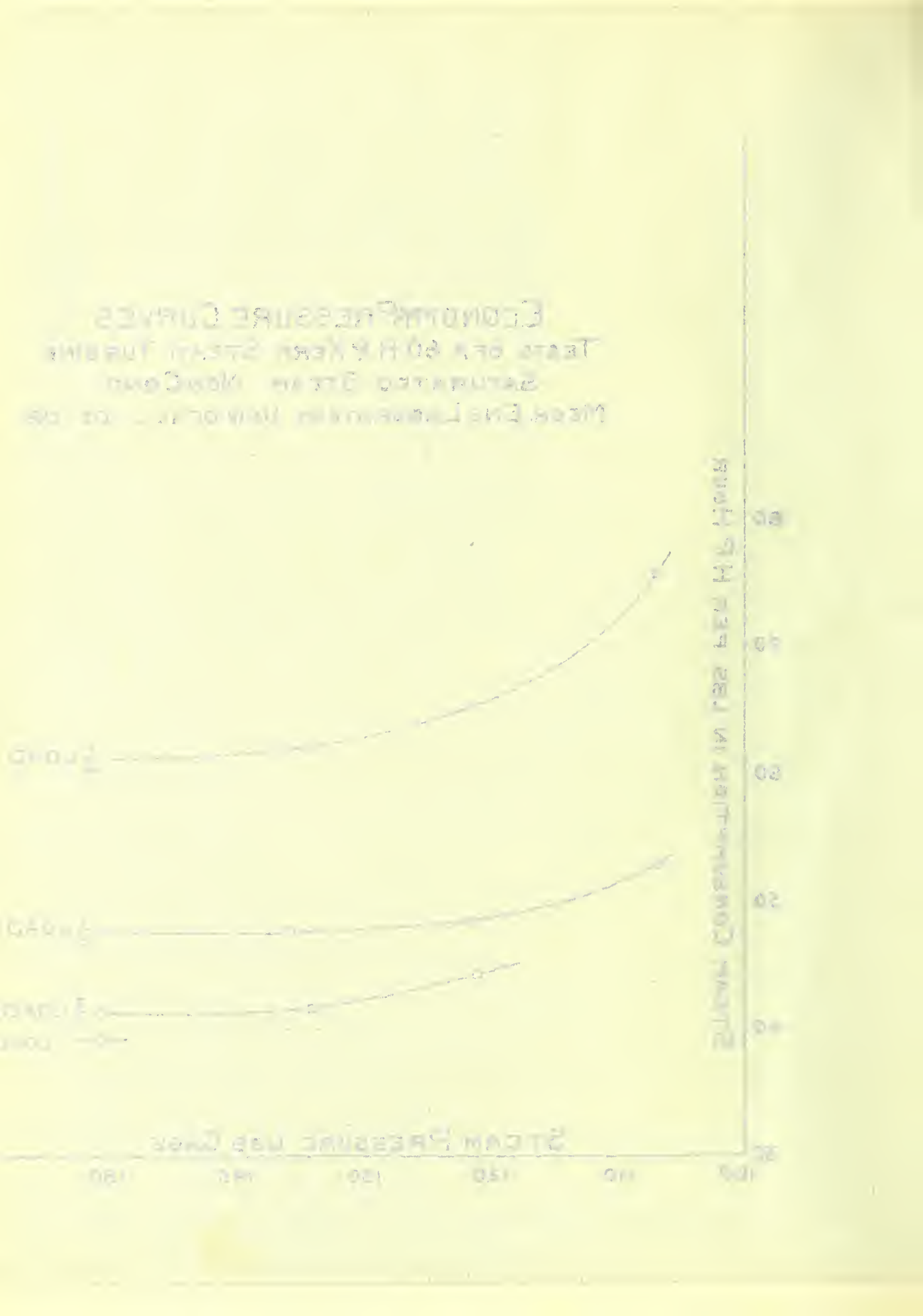
TESTS OF A 60 H.P. KERR STEAM TURBINE
SATURATED STEAM NON-COND.
MECH. ENG. LABORATORY - UNIV. OF ILL. '07-'08
LINE PRESSURE - 105#

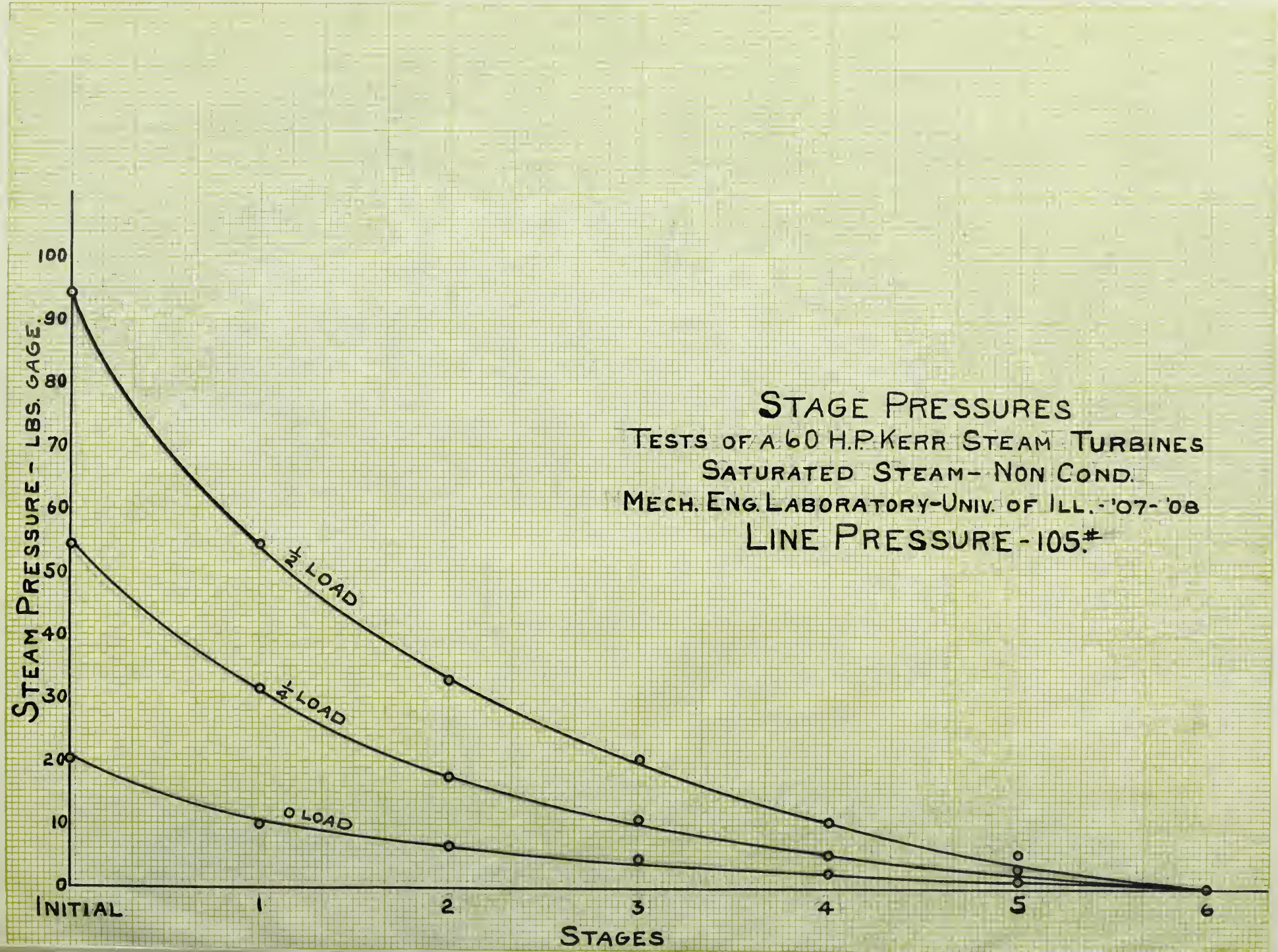





STAGE PRESSURES
TESTS OF A 60 H.P. KERR STEAM TURBINE
SATURATED STEAM - NON COND.
MECH. ENG. LABORATORY - UNIV. OF ILL '07-'08
LINE PRESSURE - 150#
STAGE PRESSURES - LBS. GAGE
160
140
120
100
80
60
40
20
0
FULL LOAD
¾ LOAD
½ LOAD
¼ LOAD
0 LOAD
INITIAL
1
2
3
4
5
6
STAGES


ECONOMY-PRESSURE CURVES
TESTS OF A 60 H.P. KERR STEAM TURBINE
SATURATED STEAM NON-COND.
MECH. ENG. LABORATORY UNIV. OF ILL. '07 - '08
STEAM CONSUMPTION IN LBS. PER H.P. HOUR
80
70
60
50
40
30
100
110
120
130
140
150
STEAM PRESSURE LBS GAGE
1/4 LOAD
1/2 LOAD
3/4 LOAD
1 LOAD

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SATURATED STEAM - NON COND.
MECH. ENG. LABORATORY - UNIV. OF ILL. - '07 - '08
LINE PRESSURE - 105#
STEAM PRESSURE - LBS. GAGE.
100
90
80
70
60
50
40
30
20
10
0
FULL LOAD
¾ LOAD
¼ LOAD
O LOAD
INITIAL
1
2
3
4
5
6
STAGES

STEAM PRESSURE - LBS GAGE.
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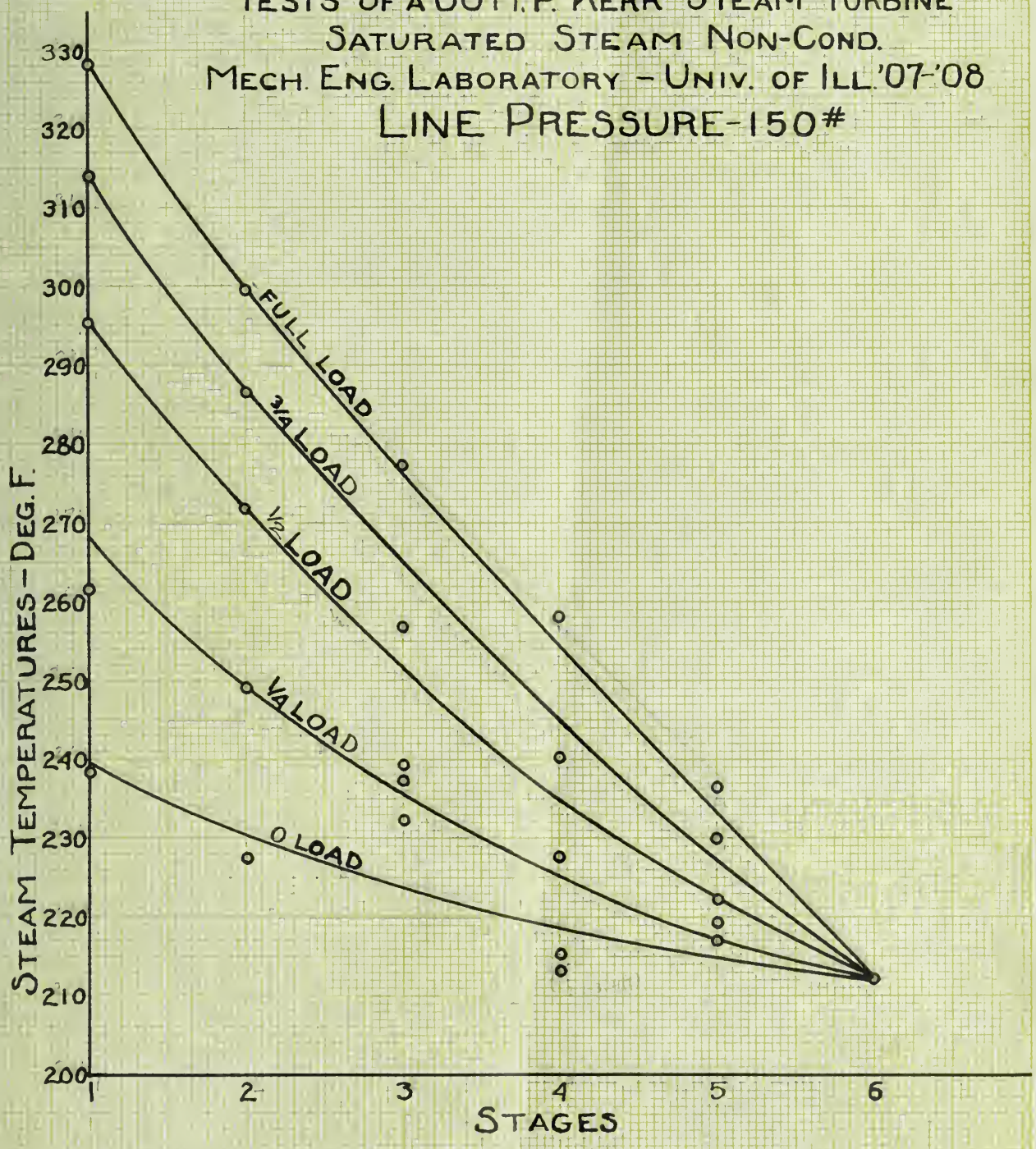
39

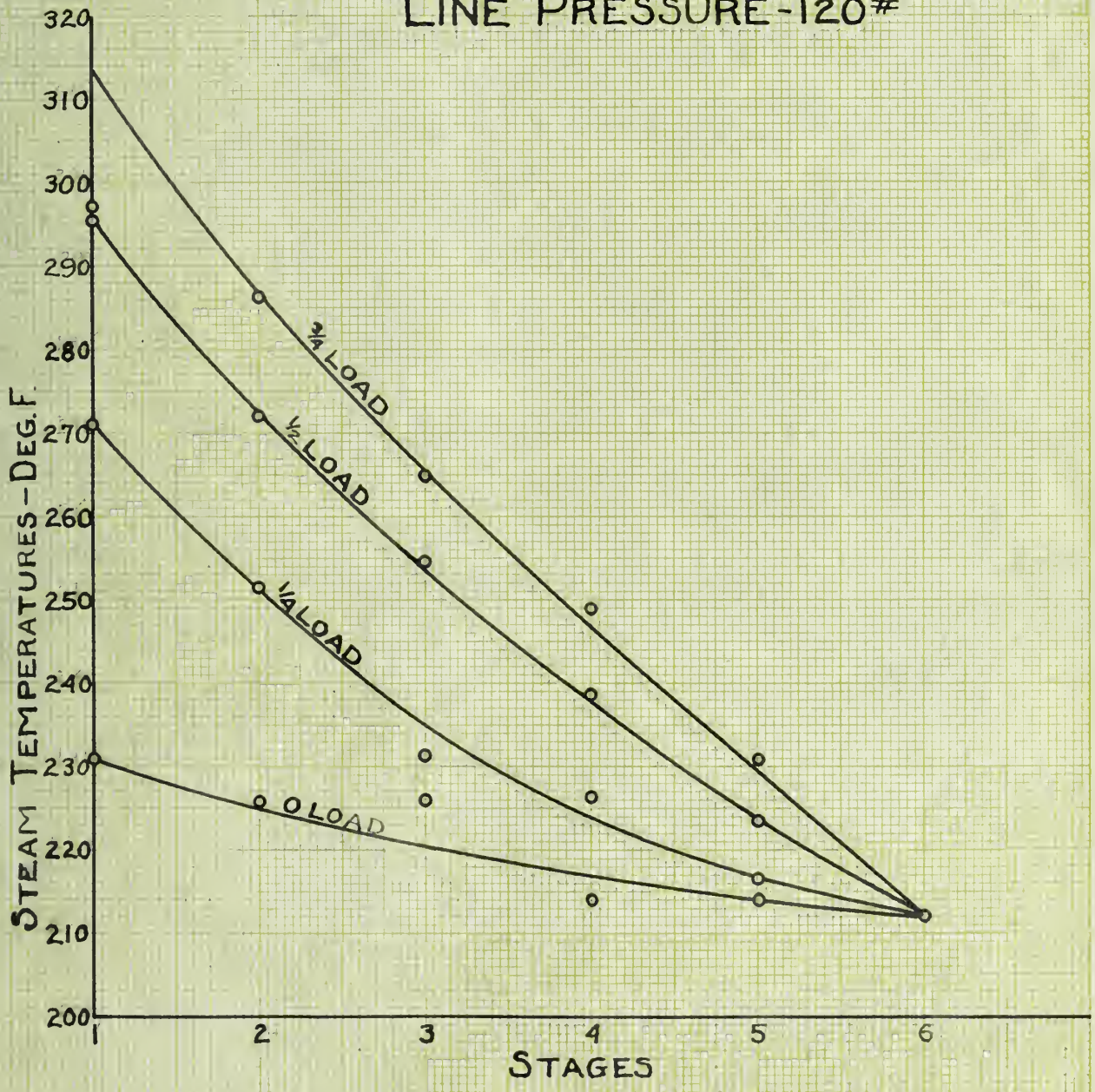
STAGE TEMPERATURES

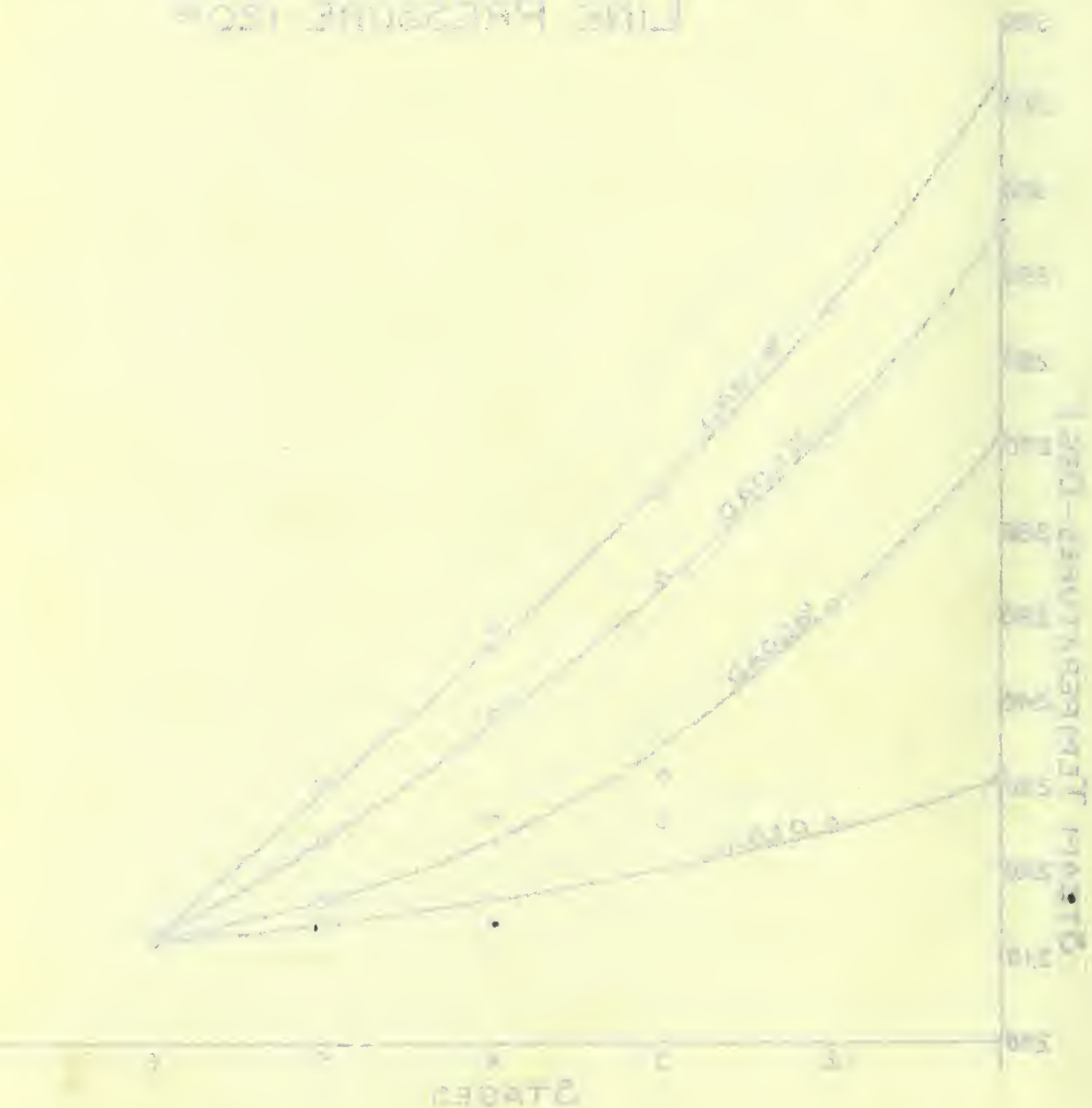
TESTS OF A 60 H.P. KERR STEAM TURBINE
SATURATED STEAM NON-COND.
MECH. ENG. LABORATORY – UNIV. OF ILL. '07-'08
LINE PRESSURE-150#



STAGE TEMPERATURES

TESTS OF A 60 H.P. KERR STEAM TURBINE
SATURATED STEAM NON-COND.
MECH. ENG. LABORATORY - UNIV. OF ILL. '07-'08.
LINE PRESSURE - 120#





150#
1-Load

STEAM ECONOMY TESTS OF A 60 H.P. KERR STEAM TURBINE

TEST NO. 1

DATE: 12-7-'07.

A.S BUYERS.

C.S. PILLSBURY.

AVERAGE B.H.P = 57.8

AVERAGE QUALITY = .976

AVERAGE STEAM ECONOMY = 39.2

AVERAGE THERMAL EFFICIENCY = .064

				TEMPERATURES.									PRESSURES.						
							STAGE.								STAGE.				
NO.	TIME	R.P.M.	WATER	EXT AIR	ENG. ROOM	CAL.	1	2	3	4	5	6	CAL	INT.	1	2	3	4	5	6
1	2:31	3500	0			271	327	298	277	258	237	213	149	150	91	57	36	20.5	11.5	0
2	:36	3520	200	45.0	76.0	265	328	299	278	258	237	213	151	152	92	57	37	20.8	11.7	0
3	:41	3650	398			266	329	300	278	258	237	213	151	152	93	57	37	20.5	11.7	0
4	:46	3710	592	45.5	76.5	271	328	300	277	258	237	213	151	152	92	57	37	20.7	11.8	0
5	:51	3583	792			270	330	301	277	259	237	213	151	152	92	57	37	20.5	11.7	0
6	:56	3590	989	45.5	77.0	276	328	300	277	258	237	213	151	152	92	57	36	20.6	11.7	0
7	3:01	3602	1097			274	328	299	278	258	237	213	151	151	92	57	37	20.8	11.7	0
8	:06	3600	1206			271	328	299	277	258	237	213	151	151	92	57	37	20.5	11.6	0
9	:11	3630	1506			260	328	299	277	258	237	213	151	152	92	58	37	20.5	11.5	0
10	:16	3658	1697	45.5	64.0	258	328	299	277	258	237	213	151	152	93	58	37	20.7	11.7	0
11	:21	3638	1890			272	328	299	277	258	237	213	151	152	93	57	37	20.8	11.7	0
12	:26	3588	2101			273	329	300	277	258	237	213	151	151	92	57	36	20.5	11.6	0
13	:31	3606	2309			276	327	299	276	258	237	213	151	152	92	57	36	20.3	11.4	0
14	:36	3685	2517			266	327	299	277	258	237	213	151	151	92	57	37	20.7	11.8	0
15	:41	3700	2676	45.0	77.0	250	327	300	277	258	237	213	151	151	92	57	36	20.5	11.6	0
16	:46	3600	2889			245	328	300	277	258	237	213	151	150	92	57	37	20.5	11.7	0
17	:51	3590	3060			248	328	299	277	258	237	213	150	149	92	57	37	20.4	11.5	0
18	:56	3600	3260	45.0	79.0	268	330	301	278	259	237	213	151	151	92	58	37	20.6	11.7	0
19	4:01	3560	3459			242	328	299	277	258	237	213	151	152	92	58	37	20.9	11.9	0
20	:06	3710	3653			246	328	299	277	258	237	213	150	150	92	57	37	20.6	11.8	0
21	:11	3648	3854	45.0	77.0	266	328	300	277	258	237	213	151	150	92	57	37	20.7	11.6	0
22	:16	3650	4041			273	328	299	277	258	237	213	151	152	92	57	37	20.5	11.5	0
23	:21	3700	4244	45.0	79.0	272	328	299	277	258	237	213	151	151	92	58	37	20.9	11.8	0
24	:26	3680	4447			271	329	300	278	258	237	213	151	151	92	57	37	20.7	11.8	0
25	:31	3618	4637			258	328	300	277	258	237	213	151	152	92	57	37	20.7	11.7	0
AVERAGE		3625		45.2	75.7	266.3	328.1	299.6	277.3	258.1	237	213	150.8	151.2	92	57.2	36.8	20.6	11.7	0

REMARKS:

BAROMETER = 29.37"

THESIS FOR BS IN MECH ENG '07-'08.

150 #
3/4-Load

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 2

Date:- 12-14-'07.

A.S. Buyers.

C.S. Pillsbury.

Average B.H.P = 45.3

Average Quality = .972

Average Steam Economy = 41.5

Average Thermal Efficiency = .060

				Temperatures.									Pressures.							
							Stage.								Stage.					
No.	Time	R.P.M.	Water	Ext Air	Eng. Room	Cal.	1	2	3	4	5	6	Cal.	Int.	1	2	3	4	5	6
1	11:10	3615	0		73.0	257	315	288	268	240	231	212	151	122	73	45	29	15.2	8.5	0
2	:15	3625	161			276	314	288	268	240	231	212	151	124	73	45	29	15.2	8.5	0
3	:20	3634	326	35.0	73.4	268	314	287	267	240	230	212	151	122	73	45	28	15.0	8.4	0
4	:25	3610	497			275	315	287	267	241	231	212	151	124	75	45	28	15.3	8.3	0
5	:30	3660	658	33.5	75.0	239	315	288	267	239	230	212	151	121	73	44	28	14.9	8.3	0
6	:35	3647	822			253	314	288	260	240	230	212	151	123	73	44	28	15.0	8.6	0
7	:40	3618	985		75.4	277	314	287	254	239	230	212	151	122	73	44	28	15.0	8.3	0
8	:45	3641	1142	33.5		277	314	287	255	239	230	212	151	121	73	44	28	15.0	8.3	0
9	:50	3608	1307		76.2	263	314	287	255	240	230	212	151	121	73	44	28	15.0	8.5	0
10	:55	3606	1472			260	314	287	255	240	230	212	151	121	73	44	28	15.0	8.5	0
11	12:00	3611	1631		73.0	257	313	287	254	240	230	212	151	121	73	44	28	14.9	8.5	0
12	:05	3605	1790			275	314	287	255	240	230	212	151	122	74	44	29	15.1	8.6	0
13	:10	3608	1952	33.6	76.0	277	314	286	254	240	230	212	151	121	73	44	29	15.0	8.5	0
14	:15	3647	2108			251	313	286	254	240	229	212	151	120	73	43	28	14.8	8.4	0
15	:20	3618	2266		75.5	241	313	286	253	240	229	212	151	120	72	43	28	14.7	8.4	0
16	:25	3598	2425			252	313	286	254	240	229	212	149	121	72	44	28	14.8	8.5	0
17	:30	3616	2588		77.0	252	313	286	254	240	229	212	149	121	72	43	28	14.6	8.3	0
18	:35	3635	2749	33.8		262	312	286	254	238	230	212	151	118	72	44	28	15.0	8.4	0
19	:40	3608	2910		77.0	269	313	286	254	239	230	212	151	120	72	44	28	14.8	8.4	0
20	:45	3627	3060			243	313	286	254	240	230	212	151	121	72	44	28	14.8	8.4	0
21	:50	3605	3220		69.5	236	313	287	254	240	230	212	151	120	73	44	28	15.0	8.5	0
22	:55	3607	3383	33.5		236	313	287	254	239	230	212	151	122	73	44	28	15.0	8.5	0
23	1:00	3604	3553		77.5	250	314	287	254	239	230	212	151	122	74	44	28	15.0	8.5	0
24	:05	3575	3716			271	313	286	254	243	230	212	151	120	72	46	29	15.0	8.3	0
25	:10	3625	3880	34.0	77.6	244	313	286	254	241	230	212	151	122	73	44	28	15.0	8.5	0
Average		3618		33.9	75.2	260.4	313.7	286.6	256.9	240.2	230	212	150.8	121.7	72.8	44.1	28.1	15.0	8.4	0

Remarks:

Barometer = 28.64"

Thesis for BS in Mech Eng. '07-'08.

150 #
½-Load.

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 3

Date:- 12-14-'07.

A.S. Buyers.

C.S. Pillsbury.

Average B.H.P. = 30.4

Average Quality = .982

Average Steam Economy = 47.6

Average Thermal Efficiency = .052

				Temperatures.										Pressures.							
							Stage.									Stage.					
No.	Time	R.P.M.	Water	Ext Air	Eng. Room	Cal.	1	2	3	4	5	6	Cal	Int.	1	2	3	4	5	6	
1	1:15	3710	0	33.5	67.5	265	297	272	247	234	222	212	151	83	51	30	19	9.3	5.6	0	
2	:20	3592	120			274	294	270	245	235	222	212	151	85	51	30	18	9.2	5.5	0	
3	:25	3570	240			277	294	270	240	230	222	212	151	85	51	30	19	9.1	5.5	0	
4	:30	3600	366			276	295	270	240	232	222	212	151	84	51	29	19	9.3	5.5	0	
5	:35	3604	486	33.5	79.0	272	294	270	238	230	222	212	151	86	51	29	19	9.2	5.5	0	
6	:40	3609	605			275	294	271	237	228	222	212	151	85	51	30	19	9.2	5.5	0	
7	:45	3611	727			273	295	271	237	228	222	212	151	86	52	30	19	9.3	5.5	0	
8	:50	3610	848			275	294	271	237	228	222	212	151	85	51	30	19	9.3	5.5	0	
9	:55	3613	967	33.8		272	295	271	236	226	222	212	151	86	51	30	19	9.2	5.5	0	
10	2:00	3599	1096		79.0	274	295	271	237	226	222	212	150	86	51	30	19	9.3	5.5	0	
11	:05	3570	1218			268	295	271	237	226	222	212	151	87	51	30	19	9.5	5.7	0	
12	:10	3625	1341			269	295	272	237	227	222	212	151	87	51	30	19	9.5	5.6	0	
13	:15	3600	1464			272	296	272	237	227	222	212	151	87	51	30	19	9.5	5.6	0	
14	:20	3603	1583			268	296	272	237	226	222	212	151	87	52	30	19	9.5	5.6	0	
15	:25	3630	1705	34.0	79.0	275	296	272	237	225	222	212	151	88	52	30	19	9.5	5.6	0	
16	:30	3602	1829			275	296	272	237	227	222	212	151	88	52	30	19	9.5	5.6	0	
17	:35	3604	1959			277	296	272	237	227	222	212	151	88	53	30	19	9.5	5.6	0	
18	:40	3601	2081			278	296	272	237	228	222	212	150	89	53	31	19	9.7	5.8	0	
19	:45	3621	2208			259	297	272	237	228	222	212	151	89	53	31	20	9.7	5.8	0	
20	:50	3603	2333	33.8	76.2	273	297	272	237	228	222	212	151	90	53	31	20	9.7	5.8	0	
21	:55	3625	2454			270	295	271	237	226	222	212	151	87	51	30	19	9.3	5.6	0	
22	3:00	3606	2576			267	295	271	236	226	222	212	151	87	51	30	19	9.3	5.6	0	
23	.05	3610	2696			275	295	271	236	225	222	212	151	85	50	31	19	9.2	5.5	0	
24	:10	3615	2824			275	295	271	236	226	222	212	151	87	51	30	19	9.2	5.6	0	
25	:15		2944	33.5	78.0	277	295	271	236	226	222	212	151	87	51	30	19	9.3	5.6	0	
Average		3609		33.8	76.5	272.5	295.3	271.9	237.6	227.8	222.	212	150.9	86	51.5	30.2	19	9.4	5.6	0	

Barometer = 27.81"

Remarks:

Thesis for BS in Mech. Eng. '07-'08.

150 #
¼-Load

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine

Test No. 4

Date: 1-4-'08.

A S Buyers.

C S. Pillsbury.

Average B. H. P = 15.29

Average Quality = .996

Average Steam Economy = 67.2

Average Thermal Efficiency = .037

				Temperatures.										Pressures.							
							Stage.									Stage					
No.	Time	RPM.	Water	Ext Air	Eng. Room	Cal.	1	2	3	4	5	6	Cal	Int.	1	2	3	4	5	6
1	9:10	3618	0	42.5	74.5	299	262	243	238	216	218	212	151	55	37	19	11.2	5.1	3.8	0
2	:15	3625	94			299	263	252	239	215	218	212	151	55	32	19	11.2	5.1	3.7	0
3	:20	3606	175	43.0	74.0	300	262	251	239	214	217	212	151	54	33	19	11.1	5.1	3.7	0
4	:25	3610	275			300	262	251	238	214	217	212	151	53	30	18	11.1	5.0	3.5	0
5	:30	3604	345			300	262	251	238	214	217	212	151	53	31	18	11.1	5.0	3.5	0
6	:35	3588	430			300	263	251	238	214	216	212	151	53	31	17	11.1	5.0	3.5	0
7	:40	3605	511	43.0	74.0	300	263	251	238	214	217	212	151	54	31	17	11.2	5.0	3.5	0
8	:45	3602	598			300	262	251	238	214	217	212	151	54	31	17	11.1	5.0	3.5	0
9	:50	3604	691			300	262	251	238	214	217	212	151	53	31	17	11.1	5.0	3.5	0
10	:55	3604	792	43.0	76.0	303	262	251	238	214	217	212	151	52	31	18	11.1	5.0	3.5	0
11	10.00	3608	865			300	262	251	238	214	217	212	151	54	31	18	11.2	5.0	3.5	0
12	:05	3607	949			301	262	251	238	214	217	212	151	54	31	18	11.2	5.0	3.6	0
13	:10	3610	1033	43.0		300	262	251	238	214	217	212	151	53	31	18	11.2	5.0	3.6	0
14	:15	3605	1121			302	262	251	238	214	217	212	151	54	31	18	11.2	5.0	3.6	0
15	:20	3612	1208			300	263	251	238	214	217	212	151	54	32	18	11.2	5.0	3.6	0
16	:25	3607	1304		75.0	300	262	251	238	214	217	212	151	52	32	18	11.2	5.0	3.6	0
17	:30	3598	1375			300	262	251	238	214	217	212	151	53	31	17	11.1	5.0	3.5	0
18	:35	3612	1455			300	261	251	238	214	217	212	151	53	31	17	11.1	5.0	3.6	0
19	:40	3608	1539			300	261	251	238	214	217	212	151	53	31	18	11.2	5.0	3.6	0
20	:45	3619	1633			299	262	251	230	214	217	212	151	53	31	18	11.3	5.0	3.6	0
21	:50	3614	1725			300	262	251	238	214	217	212	151	54	31	18	11.3	5.0	3.7	0
22	:55	3618	1821			300	262	252	238	214	217	212	151	54	32	18	11.3	5.0	3.6	0
23	11:00	3630	1902			299	262	252	238	214	217	212	151	55	32	18	11.8	5.1	3.7	0
24	:05	3622	1986			298	262	252	238	214	217	212	146	54	32	18	11.7	5.0	3.7	0
25	:10	3624	2071			298	262	252	238	214	217	212	150	55	32	18	11.7	5.1	3.6	0
Average		3610		42.9	74.5	300	262	250	238	*219.1	217	212	150.8	53.7	31.6	17.8	11.2	5.0	3.6	0

Barometer = 28.33"

Remarks: *Probably Read 224.

Thesis for BS in Mech. Eng. '07-'08.

150 #
0-Load.

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 5

Date: 1-4-'08

A.S. Buyers

C.S. Pillsbury.

Average B.H.P. = 0

Average Quality = .996

Average Steam Economy = —

Average Thermal Efficiency = —

No.	Time	R.P.M.	Water	Temperatures.									Pressures.							
				Ext Air	Eng Room	Cal	Stage 1	2	3	4	5	6	Cal	Int.	Stage 1	2	3	4	5	6
1	11:31	3684	0	44	77	300.	239	229	234	215	218	212	151	20	15	5.0	4.5	2.0	2.0	0
2	11:36	3680	28			299.	238	229	235	215	219	212	151	19	11	5.0	4.5	2.0	2.0	0
3	11:41	3690	81			300	239	229	233	215	221	212	151	19	11	5.0	4.5	2.0	2.0	0
4	11:46	3600	122			300	238	227	233	215	220	212	151	19	12	5.0	4.5	2.0	2.3	0
5	11:51	3594	166			301	238	228	231	215	220	212	151	20	11	5.0	4.7	2.0	2.3	0
6	11:56	3600	213			300	238	228	230	215	218	212	151	20	13	5.0	4.7	2.0	2.3	0
7																				
8																				
9																				
10																				
11																				
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				
21																				
22																				
23																				
24																				
25																				
Average		3641		44	77	300	238.4	227.7	232.7	215	219.3	212	151.0	19.5	12.1	5.0	4.6	2	2.1	0

Barometer = 28.34"

Remarks: Steam Flow = 508.# per hr.
Thesis for BS in Mech Eng. '07-'08.

135 #
3/4-Load

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 6

Date: 11-23-'07.

A.S. Buyers

C.S. Pillsbury.

Average B.H.P. = 45.3

Average Quality = .979

Average Steam Economy = 41.8

Average Thermal Efficiency = .060

No.	Time	RPM.	Water	Temperatures.									Pressures.							
				Ext Air	Eng. Room	Cal.	Stage. 1	2	3	4	5	6	Cal	Int.	Stage. 1	2	3	4	5	6
1	2:08	3703	0		71	260	314	289	267	250	232	213	137	123	75	46	29	15.8	8.6	0
2	:13	3605	162			273	313	288	266	249	231	213	137	122	74	46	28	15.5	8.5	0
3	:18	3610	326		72	255	312	287	266	249	231	213	137	121	74	45	28	15.4	8.4	0
4	:23	3597	488			271	306	287	265	249	231	213	137	123	74	46	29	15.3	8.4	0
5	:28	3620	650		70	274	296	287	265	249	231	213	137	120	73	45	28	15.0	8.4	0
6	:33	3630	810			274	293	286	265	249	231	213	137	120	72	45	28	15.0	8.4	0
7	:38	3610	969		70	273	293	286	265	249	231	213	137	121	74	45	29	15.0	8.4	0
8	:43	3604	1133			262	294	286	265	249	231	213	134	122	73	45	29	15.4	8.4	0
9	:48	3615	1295		69	264	293	286	265	249	231	213	137	120	73	44	28	15.0	8.4	0
10	:53	3601	1455			265	293	287	265	249	231	213	137	120	73	45	28	15.0	8.3	0
11	:58	3620	1620		70	265	292	286	264	248	231	213	137	120	72	43	28	15.0	8.3	0
12	3:03	3612	1776			241	293	286	264	248	231	213	137	120	71	43	28	15.0	8.2	0
13	:08	3605	1933		70	266	295	288	266	249	231	213	134	123	75	45	29	15.5	8.3	0
14	:13	3610	2092			268	294	288	265	249	231	213	131	121	74	45	30	15.2	8.4	0
15	:18	3599	2258		70	260	294	287	265	249	231	213	136	120	74	45	28	15.0	8.3	0
16	:23	3612	2420			272	292	287	264	248	231	213	137	121	74	44	29	15.0	8.4	0
17	:28	3640	2584		70	273	294	286	264	248	230	213	135	118	71	43	28	14.8	8.2	0
18	:33	3595	2741			273	294	287	265	249	231	213	129	123	75	45	29	15.2	8.4	0
19	:38	3610	2904		70	270	293	287	265	249	231	213	129	122	73	45	29	15.3	8.5	0
20	:43	3605	3064			267	292	287	265	248	230	213	130	119	72	43	28	14.8	8.2	0
21	:48	3603	3221		71	266	291	286	265	248	231	213	132	120	72	44	28	15.0	8.3	0
22	:53	3600	3384			249	292	286	264	248	230	213	137	120	72	43	28	14.8	8.2	0
23	:58	3630	3539		71	262	292	286	265	248	231	213	140	120	72	44	28	15.0	8.3	0
24	4:03	3610	3695			270	292	286	264	249	231	213	135	120	73	44	28	15.0	8.3	0
25	4:08	3615	3858		71	268	294	287	265	249	231	213	134	122	72	44	28	15.2	8.4	0
Average		3614			70.4	267.7	296.9	286.6	265.1	248.7	231.	213	135.2	120.7	73	44.4	28.2	15.1	8.4	0

Remarks:

Barometer = 29.55"

Thesis for BS in Mech Eng '07-'08.

135 #
½-Load.

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 7

Date - 12-7-07

A.S. Buyers

C.S. Pillsbury.

Average B.H.P. = 30.1

Average Quality = .981

Average Steam Economy = 47.7

Average Thermal Efficiency = .053

				Temperatures.										Pressures.							
							Stage.									Stage					
No.	Time	RPM.	Water	Ext Air	Eng. Room	Cal.	1	2	3	4	5	6	Cal.	Int.	1	2	3	4	5	6
1	11:35	3593	0	45	75	271	295	271	254	238	223	212	136	89	53	32	19.3	9.8	5.7	0
2	:40	3597	131			270	295	271	253	237	223	212	136	88	52	31	19.2	9.8	5.6	0
3	:45	3596	246	45	74	270	295	271	253	238	223	212	136	88	52	31	19.1	9.8	5.6	0
4	:50	3598	373			271	294	271	253	237	223	212	136	88	52	31	19.1	9.8	5.5	0
5	:55	3590	495	45	75	271	294	271	254	238	223	212	136	89	53	31	19.2	9.8	5.5	0
6	12:00	3603	641			265	286	271	253	237	223	212	136	87	52	30	18.8	9.6	5.5	0
7	:05	3603	756	45	76	269	285	270	253	238	223	212	136	87	52	29	18.8	9.7	5.5	0
8	:10	3590	875			272	285	270	253	237	223	212	136	86	51	31	18.7	9.7	5.5	0
9	:15	3586	946	44	76	270	284	271	253	236	223	212	136	88	52	31	18.9	9.7	5.6	0
10	:20	3588	1017			267	284	270	253	238	223	212	136	87	52	30	19.0	9.6	5.5	0
11	:25	3600	1241	44	76	267	283	269	252	236	222	212	136	85	51	30	18.6	9.2	5.3	0
12	:30	3606	1355			270	283	270	252	237	223	212	136	85	50	30	18.7	9.5	5.3	0
13	:35	3605	1477			270	284	270	253	238	223	212	136	86	51	31	18.8	9.5	5.5	0
14	:40	3600	1601	44	76	271	284	271	253	237	223	212	136	87	52	30	18.7	9.5	5.4	0
15	:45	3595	1716			272	282	270	253	237	223	212	136	87	51	30	18.8	9.6	5.5	0
16	:50	3588	1867	43	75	273	284	271	254	237	223	212	136	88	52	31	19.2	9.8	5.5	0
17	:55	3593	1980			272	284	271	253	238	223	212	136	87	51	30	18.9	9.7	5.5	0
18	1:00	3603	2102	43	75	271	284	270	253	237	223	212	136	86	51	30	18.7	9.4	5.4	0
19	:05	3600	2216			272	284	271	253	237	223	212	136	87	52	30	18.8	9.5	5.4	0
20	:10	3597	2319	44	63	271	284	270	253	237	223	212	136	87	52	30	18.8	9.5	5.4	0
21	:15	3593	2442			267	283	271	253	237	223	212	136	88	52	30	18.8	9.5	5.4	0
22	:20	3602	2568	44	74	265	283	270	253	238	223	212	136	87	52	30	18.8	9.5	5.4	0
23	:25	3600	2687			267	285	271	253	238	223	212	136	87	52	30	18.8	9.6	5.4	0
24	:30	3608	2808	44	76	268	284	270	252	237	223	212	136	87	51	30	18.6	9.4	5.4	0
25	:35	3602	2929			268	285	271	254	237	223	212	136	86	53	31	19.2	9.8	5.6	0
Average		3597		44	74	269.6	286.2	270.7	253.0	237.2	223.	212.	136.0	87.0	51.8	30.3	18.9	9.6	5.5	0

Barometer = 29.40"

Remarks:

Thesis for BS in Mech. Eng. '07-'08.

135 #=
1/4-Load.

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine

Test No. 8

Date - 12-7-'07.

A.S Buyers

C.S. Pillsbury.

Average B.H.P = 15.2

Average Quality = .976

Average Steam Economy = 62.0

Average Thermal Efficiency = .040

				Temperatures.										Pressures.							
							Stage.									Stage.					
No.	Time	R.P.M.	Water	Ext Air	Eng. Room	Cal.	1	2	3	4	5	6	Cal	Int.	1	2	3	4	5	6
1	9:20	3591	0			222	274	252	236	226	217	212	136	55	33	18	11.6	5.1	3.5	0
2	:25	3588	79			242	274	251	236	226	217	212	136	55	33	18	11.4	5.1	3.5	0
3	:30	3602	169			258	273	251	236	226	217	212	136	55	32	17	11.0	5.1	3.5	0
4	:35	3600	252		73	260	273	251	236	226	217	212	136	55	32	18	11.2	5.1	3.5	0
5	:40	3590	334	43.		254	274	251	235	226	217	212	136	55	32	17	11.0	5.1	3.5	0
6	:45	3600	419		71	258	273	251	235	226	217	212	136	55	32	17	11.0	5.1	3.5	0
7	:50	3598	509			259	273	251	236	226	217	212	136	54	32	17	10.9	5.1	3.5	0
8	:55	3603	596	42	72	255	273	251	235	225	217	212	136	55	32	17	11.0	5.1	3.6	0
9	10:00	3599	668			261	273	251	236	225	217	212	136	55	32	17	11.0	5.1	3.6	0
10	:05	3603	752	42	72	259	273	251	235	225	217	212	136	54	32	17	11.1	5.1	3.6	0
11	:10	3594	836			262	273	251	235	225	217	212	136	55	32	17	11.1	5.1	3.5	0
12	:15	3602	921	42	72	262	274	251	236	225	217	212	136	55	32	17	11.3	5.1	3.6	0
13	:20	3603	1006			266	273	251	235	225	217	212	136	55	32	18	11.3	5.1	3.6	0
14	:25	3596	1085	43	72	264	273	251	235	225	217	212	136	55	32	18	11.1	5.1	3.6	0
15	:30	3600	1170			265	273	251	235	225	217	212	136	55	32	17	10.9	5.0	3.5	0
16	:35	3595	1239	43	73	264	271	249	234	225	216	212	136	53	31	17	10.6	4.9	3.4	0
17	:40	3602	1327			264	272	251	235	225	216	212	136	55	31	18	11.2	5.1	3.6	0
18	:45	3604	1384	43	74	266	272	250	235	225	216	212	136	53	31	17	10.8	5.0	3.5	0
19	:50	3601	1469			266	272	249	234	225	216	212	136	52	31	17	10.7	4.9	3.5	0
20	:55	3604	1549	44	74	269	272	250	234	226	216	212	136	53	31	17	10.7	4.9	3.4	0
21	11:00	3603	1623			271	272	250	234	225	216	212	136	53	31	17	10.7	4.9	3.5	0
22	:05	3604	1703	44	69	263	272	249	234	226	216	212	136	52	31	17	10.7	4.9	3.4	0
23	:10	3600	1779			269	272	250	235	226	216	212	136	53	31	17	10.8	5.0	3.5	0
24	:15	3598	1856	44	74	263	272	250	235	225	216	212	136	52	30	17	10.8	4.9	3.5	0
25	:20	3605	1936			270	272	250	235	226	216	212	136	52	31	17	10.8	5.0	3.5	0
Average		3599		43.	72	260.5	272.7	250.7	235.2	225.7	216.3	212	136	54.1	31.6	17.6	10.9	5.0	3.5	0

Barometer = 29.45"

Remarks:

Thesis for BS in Mech. Eng. '07-'08.

135 #
0-Load.

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 9

Date: 2-22-08

A.S Buyers

C.S. Pillsbury.

Average B.H.P. = 0

Average Quality = .985

Average Steam Economy = —

Average Thermal Efficiency = —

Steam Flow = 511# per hr.

No.	Time	R.P.M.	Water	Temperatures. Ext Air	Eng. Room	Cal.	Stage. 1	2	3	4	5	6	Pressures. Cal	Int.	Stage. 1	2	3	4	5	6
1	9:26	3573	0			278	228	227	228	204	212	211	136	23	8.5	5.0	4.7	2.0	1.0	0
2	9:31	3578	45			278	232	227	227	207	212	211	133	21	9.0	5.0	4.7	2.0	1.2	0
3	9:36	3650	90			275	234	229	227	207	213	211	134	23	10.0	6.0	5.1	2.0	1.2	0
4	9:41	3625	135			278	233	227	227	213	214	211	139	22	10.0	8.0	4.9	1.7	1.2	0
5	9:46	3630	178			279	233	227	227	206	214	211	138	22	10.0	8.0	4.8	1.7	1.2	0
6	9:56	3600	220			278	232	226	227	207	214	211	136	20	10.0	7.0	4.6	1.7	1.2	0
7	9:56	3600	259			275	231	226	227	212	214	211	136	20	9.0	7.0	4.6	1.6	1.2	0
8																				
9																				
10																				
11																				
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				
21																				
22																				
23																				
24																				
25																				
Average		3610				277.6	231.7	226.8	227.1	207.6	213.5	211	136	21.6	9.5	6.8	4.8	1.8	1.2	0

Barometer = 29.39"

Remarks:

Thesis for B.S. in Mech. Eng. '07-'08.

120 #
3/4-Load.

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 10

Date:- 11-16-07

A.S. Buyers.

C.S. Pillsbury.

Average B.H.P. = 43.2

Average Quality = .978

Average Steam Economy = 44.4

Average Thermal Efficiency = .057

				Temperatures.									Pressures.						
				Ext	Eng.		Stage.								Stage.					
No.	Time	R.P.M.	Water	Air	Room	Cal.	1	2	3	4	5	6	Cal.	Int.	1	2	3	4	5	6
1	3:32	3588	0			265	296	287	269	249	231	212	121.5	120	72	44	29.	15.2	8.4	0
2	:35	3580	166			268	294	288	269	249	231	212	121.5	120	72	45	29	15.3	8.4	0
3	:42	3600	333			270	295	287	270	249	231	212	121.5	120	72	45	28	15.3	8.4	0
4	:47	3602	498			269	295	288	269	249	231	212	121.5	121	72	44	28	15.0	8.3	0
5	:52	3527	655			271	296	287	269	249	231	212	121.5	121	72	44	28	15.0	8.3	0
6	:57	3600	814			272	297	286	267	249	231	212	121.5	120	72	44	28	15.0	8.3	0
7	4:02	3400	968			272	297	284	267	248	230	212	118.5	118	70	44	28	14.8	7.8	0
8	:07	3406	1122			250	297	285	266	248	230	212	117.5	117	70	43	28	14.8	8.0	0
9	:12	3605	1282			241	295	287	270	249	231	212	121.5	120	72	45	28	15.5	8.4	0
10	:17	3593	1442			265	294	288	268	249	231	212	121.5	120	72	44	28	15.0	8.3	0
11	:22	3550	1602			253	298	286	269	249	231	212	121.5	120	71	44	28	15.0	8.3	0
12	:27	3618	1763			213	299	288	270	249	231	212	121.5	121	72	45	28	15.3	8.3	0
13	:32	3657	1923			233	295	287	269	249	231	212	122.5	122	72	45	29	15.3	8.4	0
14	:37	3624	2090			255	294	288	269	249	231	212	121.5	120	72	44	29	15.2	8.3	0
15	:42	3695	2260			266	296	287	270	249	231	212	121.5	120	72	44	29	15.0	8.4	0
16	:47	3603	2420			269	295	287	269	249	231	212	121.5	121	72	44	28	15.0	8.3	0
17	:52	3595	2584			269	298	286	268	249	231	212	122.5	122	72	44	28	15.0	8.3	0
18	:57	3600	2748			268	299	287	268	249	231	212	121.5	122	72	44	28	15.3	8.3	0
19	5:02	3606	2915			218	297	287	270	249	231	212	121.5	121	73	44	28	15.0	8.0	0
20	:07	3634	3082			260	296	289	268	250	231	212	121.5	121	71	44	29	15.3	8.4	0
21	:12	3566	3267			270	295	286	269	249	231	212	121.5	121	72	44	29	14.9	8.0	0
22	:17	3582	3428			270	298	286	269	248	231	212	121.5	121	72	44	28	15.2	8.3	0
23	:22	3642	3590			269	295	286	268	249	231	212	121.5	121	71	44	28	15.0	8.3	0
24	:27	3651	3751			264	295	287	270	249	231	212	121.5	121	72	44	29	15.2	8.4	0
25	:32	3622	3920			270	296	288	269	249	231	212	121.5	121	72	44	29	15.3	8.3	0
Average		3589				261.6	295.9	286.6	269.0	249.0	231.0	212	121.3	120.5	71.8	44.1	28.4	15.1	8.3	0

Barometer = 29.50"

Remarks:

Thesis for B.S. in Mech. Eng. '07-'08.

120 #
½-Load.

Steam Economy Tests of a 60 HP Kerr Steam Turbine

Test No. 11

Date: 11-23-'07

A.S Buyers

C.S. Pillsbury.

Average B.H.P = 30.2

Average Quality = .986

Average Steam Economy = 48.4

Average Thermal Efficiency = .052

				Temperatures.										Pressures.							
							Stage								Stage						
No.	Time	R.P.M.	Water	Ext Air	Eng. Room	Cal.	1	2	3	4	5	6	Cal.	Int.	1	2	3	4	5	6	
1	11:40	3560	0		70.	277	295	273	256	239	224	212	120.5	92.	53	32	21	10.2	5.7	0	
2	:45	3590	141			277	298	274	258	240	226	212	120.5	93	55	33	20	10.4	5.8	0	
3	:50	3605	269			275	298	275	256	239	224	212	121.5	92	54	32	20	10.4	5.8	0	
4	:55	3608	394			271	298	273	257	240	226	212	121.5	91	53	32	20	10.4	5.8	0	
5	12:00	3601	519		69.	270	298	273	256	239	224	212	121.5	91	53	32	20	10.2	5.7	0	
6	:05	3595	649			267	297	273	255	239	224	212	121.5	92	53	32	20	10.2	5.7	0	
7	:10	3600	770			275	296	272	256	240	224	212	121.5	91	53	32	20	10.0	5.6	0	
8	:15	3610	902			276	297	272	255	239	224	212	121.5	91	53	32	20	10.9	5.8	0	
9	:20	3612	1035		70.	277	296	272	255	237	223	212	121.5	88	51	31	19	9.6	5.5	0	
10	:25	3600	1150			276	296	272	255	238	224	212	121.5	90	53	31	20	10.0	5.7	0	
11	:30	3615	1273			275	296	272	255	239	223	212	121.5	89	52	32	20	9.8	5.6	0	
12	:35	3610	1400			271	296	271	255	238	223	212	121.5	88	52	31	19	9.6	5.4	0	
13	:40	3620	1535		71	271	295	271	255	238	223	212	121.5	87	51	31	19	9.7	5.5	0	
14	:45	3615	1637			271	296	271	255	237	223	212	121.5	88	51	31	19	9.8	5.5	0	
15	:50	3612	1759			271	295	271	254	238	224	212	121.5	88	51	31	19	9.7	5.4	0	
16	:55	3608	1881			271	294	270	254	237	223	212	121.5	86	50	31	19	9.5	5.4	0	
17	1:00	3611	2008		71	266	296	270	254	238	223	212	121.5	88	51	31	19	9.5	5.4	0	
18	:05	3601	2129			276	296	272	255	238	223	212	121.5	88	52	31	19	9.8	5.5	0	
19	:10	3603	2250			276	296	273	254	238	223	212	121.5	88	51	31	19	9.8	5.5	0	
20	:15	3605	2374			271	296	271	255	238	223	212	121.5	88	51	31	19	9.8	5.5	0	
21	:20	3607	2499		71	277	297	271	254	239	223	212	121.5	88	51	31	19	9.8	5.5	0	
22	:25	3620	2612			277	296	272	255	238	224	212	121.5	88	52	31	20	9.8	5.5	0	
23	:30	3616	2723			274	295	271	254	238	223	212	121.5	88	51	31	20	9.8	5.5	0	
24	:35	3613	2845			275	295	271	255	238	223	212	121.5	88	52	32	19	9.7	5.5	0	
25	:40	3604	2968		70	275	296	272	225	239	224	212	121.5	89	51	32	20	9.8	5.6	0	
Average		3606			70.4	275.6	295.8	272.1	254.9	238.4	223.6	212	121.5	89.2	52.	31.4	19.5	9.9	5.6	0	

Barometer = 29.55

Remarks:

Thesis for BS in Mech Eng '07-'08

120 #
¼-Load

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 12

Date:- 11-23-'07.

A.S. Buyers.

C.S. Pillsbury.

Average B.H.P = 15.4

Average Quality = .985

Average Steam Economy = 65.1

Average Thermal Efficiency = .039

				Temperatures.									Pressures.							
							Stage.								Stage.					
No.	Time	R.P.M.	Water	Ext Air	Eng. Room	Cal.	1	2	3	4	5	6	Cal.	Int.	1	2	3	4	5	6
1	9:00	3600	0			261	273	253	238	227	218	212	121	55	31	20	12	5.5	3.8	0
2	:05	3650	88			269	273	253	233	227	217	212	121	57	33	19	12	5.2	3.5	0
3	:10	3695	176			271	272	253	232	227	217	212	121	57	32	18	12	5.2	3.7	0
4	:15	3630	264			267	272	253	228	227	217	212	121	58	33	19	12	5.5	3.7	0
5	:20	3710	352			269	272	254	229	229	218	212	121	58	33	19	12	5.5	3.7	0
6	:25	3605	440			274	274	254	235	229	218	212	121	58	33	19	12	5.5	3.7	0
7	:30	3615	528	37		274	274	253	229	228	217	212	121	56	32	19	11	5.2	3.5	0
8	:35	3610	616			274	273	253	228	227	217	212	121	57	32	19	12	5.3	3.6	0
9	:40	3605	703			274	271	253	227	227	217	212	121	56	32	19	11	5.4	3.7	0
10	:45	3603	789			275	271	253	227	227	217	212	121	57	33	18	12	5.4	3.7	0
11	:50	3650	876			275	269	251	226	227	217	212	121	55	31	18	11	5.0	3.5	0
12	:55	3620	959			269	270	251	226	226	217	212	121	54	31	18	11	5.0	3.5	0
13	10:00	3640	1046			273	270	252	227	227	217	212	121	55	31	18	11	5.0	3.6	0
14	:05	3630	1136			272	269	251	227	226	217	212	121	53	31	18	11	5.0	3.5	0
15	:10	3615	1216			273	269	250	225	226	217	212	121	53	31	17	10	5.0	3.5	0
16	:15	3635	1291			272	268	250	233	225	217	212	121	52	30	17	10	5.0	3.4	0
17	:20	3700	1377			274	269	250	234	225	216	212	121	52	30	17	10	4.8	3.4	0
18	:25	3610	1457			265	269	249	235	225	216	212	121	52	30	17	11	5.0	3.5	0
19	:30	3650	1537	42		274	270	250	235	226	216	212	121	52	30	17	11	5.0	3.4	0
20	:35	3615	1617			273	271	250	236	226	216	212	121	53	30	17	11	5.0	3.5	0
21	:40	3630	1705		67.5	269	271	249	236	226	217	212	121	45	26	15	10	4.8	3.4	0
22	:45	3630	1784			277	270	249	235	225	216	212	121	49	29	17	11	4.8	3.4	0
23	:50	3670	1867		69.0	275	273	251	237	226	217	212	121	55	31	17	11	5.0	3.5	0
24	:55	3605	1952			278	272	251	236	226	217	212	121	55	31	17	11	5.0	3.5	0
25	11:00	3590	2033		69.0	275	272	251	236	226	217	212	121	53	31	18	11	5.0	3.5	0
Average		3633		39.5	68.5	272.2	271.	251.5	231.5	226.5	216.8	212	121	54.3	31.1	17.8	11.	5.1	3.6	0

Remarks:

Barometer = 29.60"

Thesis for BS in Mech. Eng. '07-'08.

120 #
0-Load

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 13

Date: 2-22-'08

A.S Buyers.

C.S. Pillsbury.

Average B.H.P = 0

Average Quality = .972

Average Steam Economy =

Average Thermal Efficiency =

Steam Flow = 476.# per hr.

				Temperatures.									Pressures.							
							Stage.								Stage.					
No.	Time	R.P.M.	Water	Ext Air	Eng. Room	Cal.	1	2	3	4	5	6	Cal	Int.	1	2	3	4	5	6
1	10:01	3622	0			254	231	226	227	212	214	211	121.5	21	9.0	8.	5.	1.7	1.2	0
2	:06	3638	44.			251	232	227	227	210	214	212	121.5	20	10.0	8.	5.	1.7	1.2	0
3	:11	3579	85.			252	231	226	227	213	214	213	121.5	18	10.0	9.	5.	1.5	1.2	0
4	:16	3585	122			247	231	226	226	214	214	215	121.5	19	9.0	8.	5.	1.6	1.2	0
5	:21	3601	164.			255	231	226	226	214	214	215	121.5	20	10.0	8.	5.	1.5	1.1	0
6	:26	3593	204			251	231	226	226	214	214	215	121.5	20	9.0	8.	5.	1.5	1.2	0
7	:31	3597	248			249	231	226	226	215	214	216	121.5	20	10.0	8.	5.	1.5	1.2	0
8	:36	3597	286			247	231	226	226	215	214	217	121.5	19	10.0	8.	5.	1.7	1.2	0
9	:41	3594	324			246	231	226	226	215	214	217	121.5	20	10.0	8.	5.	1.5	1.2	0
10	:46	3604	365			244	231	226	226	215	214	217	121.5	19	10.0	8.	5.	1.5	1.2	0
11	:51	3592	407			246	231	226	226	215	214	217	121.5	19	10.0	8.	5.	1.5	1.2	0
12	:56	3602	449			247	231	226	226	215	214	217	121.5	19	10.0	8.	5.	1.5	1.2	0
13	11:01	3604	489			245	231	226	226	215	214	217	121.5	19	10.0	8.	5.	1.5	1.2	0
14																				
15																				
16																				
17																				
18																				
19																				
20																				
21																				
22																				
23																				
24																				
25																				
Average		3600				248.6	231.0	226.1	226.2	214.0	214.0	215.3	121.5	19.4	9.8	8.1	5.	1.6	1.2	0

Barometer = 29.39

Remarks:

Thesis for BS in Mech Eng. '07-'08.

105 #
½-Load

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 14

Date: 11-16-'07.

A.S Buyers.

C.S. Pillsbury.

Average B.H.P. = 28.8

Average Quality = .983

Average Steam Economy = 52.7

Average Thermal Efficiency = .048

				Temperatures.										Pressures.						
							Stage.									Stage.				
No.	Time	RPM.	Water	Ext Air	Eng. Room	Cal.	1	2	3	4	5	6	Cal	Int.	1	2	3	4	5	6
1	1:10	3550	0			261	287	274	256	238	224	212	105	94	54	32	21	10.3	6.0	0
2	:15	3610	131			256	286	274	257	238	225	212	107	93	55	32	20	10.3	6.0	0
3	:20	3600	264			254	283	274	256	239	224	212	107	93	54	32	20	10.2	6.0	0
4	:25	3595	398			257	282	275	256	240	226	212	107	96	55	34	21	10.8	6.0	0
5	:30	3597	534			263	282	275	258	241	225	212	107	97	60	34	22	10.8	6.0	0
6	:35	3637	619			266	280	275	257	240	225	212	107	97	54	34	21	11.0	6.0	0
7	:40	3603	786			265	281	275	257	241	225	212	107	96	54	34	22	11.0	6.2	0
8	:45	3591	915			267	282	275	257	241	225	212	107	96	55	34	22	11.0	6.0	0
9	:50	3620	1032			268	282	274	257	241	225	212	107	95	56	33	21	10.7	6.0	0
10	:55	3613	1158			269	284	274	257	241	225	212	107	95	55	34	21	11.0	6.2	0
11	2:00	3595	1296			267	283	276	258	241	225	212	107	97	55	33	21	11.0	6.3	0
12	:05	3602	1423			268	284	274	257	241	225	212	107	94	57	33	21	10.0	6.0	0
13	:10	3612	1549			267	284	274	257	240	224	212	107	93	55	32	20	10.0	6.0	0
14	:15	3618	1683			268	283	274	256	239	225	212	107	92	55	33	20	11.0	6.0	0
15	:20	3615	1803			265	281	273	255	240	224	212	107	92	54	32	20	10.2	5.7	0
16	:25	3650	1924			268	281	273	255	240	224	212	107	90	53	32	20	10.2	5.7	0
17	:30	3685	2051			264	281	274	255	240	225	212	107	93	53	33	20	10.5	6.0	0
18	:35	3683	2173			248	281	273	257	240	224	212	107	93	54	32	20	10.3	6.0	0
19	:40	3704	2301			244	281	273	256	240	224	212	107	93	53	32	21	10.5	6.0	0
20	:45	3695	2478			263	282	273	256	240	224	212	107	92	53	33	20	10.5	6.0	0
21	:50	3687	2610			267	283	273	256	240	224	212	107	91	54	32	20	10.3	5.8	0
22	:55	3695	2703			269	281	274	256	240	224	212	107	93	53	32	20	10.5	6.0	0
23	3:00	3695	2833			269	280	273	256	239	224	212	107	92	54	32	20	10.3	5.8	0
24	:05	3693	2957			254	281	272	255	238	224	212	107	90	54	32	19	10.0	5.7	0
25	:10	3706	3081			263	281	273	255	238	224	212	107	93	52	32	20	10.3	5.7	0
Average		3638				262.7	282.5	273.3	256.4	239.6	224.5	212	107	93.6	54	32.8	20.6	10.5	6.0	0

Barometer = 29.50"

Remarks:

Thesis for BS in Mech. Eng. '07-'08.

105 #
¼-Load

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 15

Date: 11-16-'07.

A.S Buyers

C.S. Pillsbury.

Average B.H.P = 13.5

Average Quality = .99

Average Steam Economy = 75.6

Average Thermal Efficiency = .034

				Temperatures.										Pressures.							
							Stage.									Stage.					
No.	Time	RPM.	Water	Ext Air	Eng. Room	Cal.	1	2	3	4	5	6	Cal.	Int.	1	2	3	4	5	6
1	9:00	3618	0			278	270	251	236	223	155	212	107	53	31	16	11	5	3.4	0
2	:05	3598	115			279	269	251	236	224	226	212	107	55	32	18	11	5	3.5	0
3	:10	3617	210			280	268	252	236	224	217	212	107	54	32	18	12	5	3.5	0
4	:15	3595	290			277	266	251	236	224	216	212	106	54	31	17	11	5	3.4	0
5	:20	3546	370			276	266	251	236	226	218	211	108	54	32	17	11	5	3.5	0
6	:25	3607	455			277	267	251	236	225	217	212	107	54	31	17	11	5	3.5	0
7	:30	3560	535			276	267	251	235	225	217	212	107	54	32	18	12	5	3.5	0
8	:35	3540	615			275	266	252	236	226	217	211	107	55	32	17	12	5	3.5	0
9	:40	3592	705			275	265	252	236	226	217	212	107	55	31	17	11	5	3.5	0
10	:45	3593	809			275	265	251	236	227	217	212	107	54	31	18	11	5	3.5	0
11	:50	3612	900			276	263	251	236	226	216	212	107	53	31	18	11	5	3.5	0
12	:55	3605	977			277	264	250	235	226	216	212	107	53	31	17	11	5	3.5	0
13	10:00	3630	1059			275	263	251	235	226	217	212	107	53	31	17	11	5	3.5	0
14	:05	3605	1142			276	262	251	236	226	217	212	107	53	31	17	10	5	3.5	0
15	:10	3590	1233			275	262	251	236	226	217	212	107	55	31	17	11	5	3.5	0
16	:15	3592	1295			276	263	252	236	227	217	212	107	55	28	18	12	5	3.5	0
17	:20	3590	1386			276	260	252	237	227	217	212	107	56	31	18	12	5	3.6	0
18	:25	3590	1460			273	264	252	237	227	216	212	107	56	32	18	12	5	3.6	0
19	:30	3612	1540			274	263	252	236	226	215	212	108	55	29	17	11	5	3.5	0
20	:35	3592	1646			275	263	251	236	226	217	212	107	54	29	18	11	5	3.5	0
21	:40	3595	1733			277	262	251	236	226	217	212	107	53	31	17	11	5	3.5	0
22	:45	3603	1815			275	264	251	236	227	217	212	106	53	31	17	11	5	3.5	0
23	:50	3600	1902			276	261	250	235	226	217	212	107	53	30	17	11	5	3.3	0
24	:55	3593	1982			277	261	250	235	226	216	212	107	54	31	17	11	5	3.5	0
25	11:00	3590	2064			276	261	250	235	226	216	212	106	52	30	17	11	5	3.4	0
Average		3595				276.1	263.5	251.2	235.8	225.9	216.7	212	107	54	31.1	17.5	11.2	5	3.5	0

Barometer = 29.60"

Remarks:

Thesis for BS in Mech. Eng. '07-'08.

105 #
0-Load.

Steam Economy Tests of a 60 H.P. Kerr Steam Turbine.

Test No. 16.

Date :- 2-22-'08.

A.S. Buyers.

C.S. Pillsbury.

Average B.H.P. = 0

Average Quality = .982

Average Steam Economy = 0

Average Thermal Efficiency = 0

Average Steam Flow = 473 #/hr.

				Temperatures.										Pressures.							
							Stage.									Stage.					
No.	Time	R.P.M.	Water	Ext Air	Eng. Room	Cal.	1	2	3	4	5	6	Cal.	Int.	1	2	3	4	5	6
1	11:15	3650	0			261	232	227	226	215	214	217	107	22	10	7	5	1.7	1.2	0
2	11:20		47			263	232	226	226	215	214	217	107	20	10	7	5	1.7	1.2	0
3	11:25	3687	86			248	232	227	226	215	215	216	107	22	10	7	5	1.7	1.2	0
4	11:30		125			258	232	226	226	215	215	216	107	20	10	7	5	1.5	1.2	0
5	11:35	3618	163			259	232	226	226	215	214	216	107	20	10	7	5	1.5	1.2	0
6	11:40	3633	201			261	232	226	225	215	215	217	103	20	10	7	5	1.5	1.2	0
7	11:45	3588	246			259	231	225	225	215	215	216	106	18	10	7	5	1.2	1.2	0
8	11:50	3601	281			274	231	226	225	215	215	217	107	20	10	7	5	1.5	1.2	0
9	11:55	3605	321				232	227	226	215	215	218	108	20	10	7	5	1.5	1.2	0
10																				
11																				
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				
21																				
22																				
23																				
24																				
25																				
Average		3620				260.5	231.8	226.2	225.7	215	214.7	216.7	106.3	20.2	10	7	5	1.5	1.2	0

Barometer = 29.39"

Remarks:

Thesis for BS in Mech. Eng. '07-'08.

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